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STUDIES OF EUROPEAN WILD BOAR IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

1st Annual Report

February 1978

Report for the Superintendent

GREAT SMOKY MOUNTAIN NATIONAL PARK

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U. S. Department of the Interior
National Park Service
Uplands Field Research Lab

[redacted]

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Department of the Interior
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Twin Creeks Area
Gatlinburg, TN 37738

This report is primarily based upon one year's data and much of the results are preliminary. We are producing a limited number of copies due to the amount of public interest and controversy on the subject.

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PART I. CENSUS, TRAPPING, AND POPULATION BIOLOGY OF EUROPEAN WILD BOAR - 1977

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SUMMARY

1977 Studies

Population Studies

1. European wild boar (Sus scrofa) were trapped in a low elevation winter and a high elevation summer (11.6 square kilometers) study area and also censused in the high elevation area

2. Trap success was much higher, 1 hog per 5.3 trap nights, than in the low elevation area -- 1 hog per 68 trap nights. We were largely unsuccessful in obtaining multiple captures with a swing-style trap door. During the course of the study, wild boar learned to lift trap doors.

3. An estimated 86 to 92 wild boar inhabited the high elevation study area, or 7.4 to 7.9 boar per square kilometer; boar were disproportionately abundant in gray beech, northern hardwood, red maple - sourwood, and oak - red maple forest types.

4. In this winter, 1976-77, mast availability and winter breeding by wild boar were high; in fact, percent of sows bred in winter and summer were not significantly different (55 percent and 44 percent, respectively).

5. Average group size was only 1.87 ± 0.64 (95 percent confidence). In comparison to wild boar from native ranges, we found more solitary sows and no large "sounder" groups of sows with even-aged young.

6. Significantly more adult sows were found in the summer in the ridgeline population than in the valleys.

7. Computer simulations of harvests were conducted employing reproductive and survival figures from this study. One harvest of 50 percent had a much greater influence in population reduction than two harvests of 25 percent each in a single year. This suggests that any control efforts would need to be very intensive.

Food Habits

1. Acorns were the major dietary component at low elevations in fall, winter, and spring. Green foliage composed the bulk of the high elevation spring and summer diet (73 percent and 52 percent, respectively). More than 23 species of herbs were eaten. Roots and bulbs, largely spring beauty corms (*Claytonia virginica*), were important in spring and summer diets (25 percent and 31 percent, respectively).

2. Invertebrates were found in almost every stomach but their volume was low. Insects found were walking-sticks (Phasmatidae), Hellgramite (Corydalidae larvae), adult and larval beetles (Coleoptera), caterpillers (Lepidopter larvae), fly larvae (Diptera), and Hymenoptera. Arthropods found were millipedes (Diplopoda), centipedes (Chilopoda), snails (Gastropoda), earth worms (Oligochaeta), and crayfish (Decapoda).

3. Similarly, frequency of vertebrates was high but percent volume was low. Salamanders (7 species) were especially common. An average of 1.75 salamanders, of which 1.33 were the endemic red-cheeked, *Plethodon jordani jordani*, were found per stomach at the higher elevations.

4. Roots and tubers were much more common during the winter, 1975-76, when mast was not available, a pattern previously described by Scott and Pelton (1975).

5. Food habits were very seasonal, and hogs demonstrated great efficiency in utilizing transient food sources; e.g., serviceberries.

6. The study sites, located in long-occupied hog range, were dominated by feeding on small tubers of largely one species of flower. This further supports hypotheses of Bratton (1975)

that plant diversity is being lowered and some species of flowers are being greatly reduced by hogs, and theories of Riney (1964) and Caughley (1969) that eruptive dispersal of introduced ungulates are associated with a modification in the habitat.

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INTRODUCTION

The purpose of the first year of the present study was to estimate numbers of European wild boar (cf also European wild hog, wild boar) and to evaluate population parameters in response to management removals. Study period was October 1976 - October 1977.

METHODS

Forest Typing

The presence of tree > 10 centimeters diameter at breast height (dbh), shrub < 10 centimeters dbh, and herb species in the ridgetop study area were noted in order of apparent dominance by ocular estimate. The area was walked and the location of the changes in species composition recorded on U.S. Geological Survey topographic maps. Forest types were defined according to similarities in species composition and dominance of tree species. Area of each type was measured using a 50 x 50 meter grid overlay.

Mast Survey

Acorn production was sampled in a limited area of lower Anthony Creek drainage (four sites), fall 1977, using a binocular survey (Whitehead 1969).

Trapping

Sixteen traps were erected in the backcountry, eight at low elevations were activated in the winter and eight at high elevations in the summer. Trap doors were either guillotine-style for single release or swing style. The swing style were capable of multiple entry after initial capture closure.

Wild boar were manhandled after capture and their legs were tied. We placed radio transmitters on six animals and marked 18 other animals with numbered collars, ear tags, and, in 15 cases, with bells of varying tone. Plastic livestock tags or reflective house numbers were affixed to all marking collars.

Ten trapping sessions were conducted on the ridgetop study area and 29 different animals were captured.

Feeding Stations

Two feeding stations with nearby observation platforms were erected. The stations were supplied with about 106 liters of field corn on six occasions from June to August.

Information from Specimens

Specimens were gathered for our food habits studies (32 wild boar); for studies of diseases conducted by W. Cook, University of Tennessee (15 wild boar); and for the park's management program (98 wild boar). When possible, blood samples were taken from all freshly-killed and from some live-captured animals. Each animal harvested was weighed and measured, the lower jaw and eyeballs were taken for aging (Henson 1975), and reproductive tracts were taken from females (Duncan 1974). In total, 47

stomachs, 40 blood samples, and 88 jaws were collected. Another 15 jaws were aged in the field.

Animals under 26 months were aged by the tooth eruption pattern (Matschke 1967a; Diong 1973). All animals over 26 months were placed into preliminary age classes based upon molar and premolar wear patterns (Kozlo 1973). We acknowledge that wear patterns may be a crude technique (Dietz 1969) and that inaccurate aging is a major cause of bias in life table analysis (Caughley 1977); however, until a better technique is developed (Henson 1975) or until we can test wear patterns with our marked animals in years to come, we felt preliminary categorization was justified.

Census Observations

In order to assess population size and structure, a series of night censuses were conducted on foot along trails in the Spence Field study area. Counts were made from 8:30 p.m. to 2:00 a.m., which corresponded to a peak of feeding activity for wild boar. Data recorded were number of animals, perpendicular distance from the trail, location, forest type, and any notes on behavior or identifying marks. Wild boar were

visually classified into four age classes (Shaffer 1978; Sludskii 1954): small piglets 0-4 months old with striped pelage, large piglets 4-8 months old with unstriped or faintly striped pelage, yearlings (approximately 8-14 months), and adults (14+ months). Sex was determined wherever possible. Groups were classified, following Shaffer (1978), as: family group-- sow and young of year or yearlings; extended family group-- sow, young and yearlings; multiple-family group-- at least two sows with young. All belled animals were recorded.

Census Analysis

Strip census techniques were used to analyze night census data. For these techniques, reviewed in Caughley (1977) and Robinette et al. (1974), an observer travels along a route of known length (L) and records the distance (X) to animals. These distances are used to estimate the "effective width" of the censused strip, and thereafter the density over the entire area. Principle variations in methods involve differences in which distance is measured between animal to observer and differences in calculation of strip width.

We used two strip census techniques which employed perpendicular distance. In each, animals are assumed to be

less observable as distance from the census route increases. The probability of observation is determined by a function of that distance. Eberhardt (1969), as expanded in Caughley (1977) suggests the following model, $P_x = 1 - (\frac{X}{W})K$, where P_x is the probability of observation and is a function of W, the greatest observed distance, and K, a constant determining rate of falloff of observability. The constants K and W are fitted using the regression, $\text{Log}\ (1-P_x) = K\ (\text{Log}\ X) - K\ (\log W)$. P_x is determined by grouping observations into 10 meter intervals, with X taking the value of the midpoint. This curve is suitable when sample observability is an decreasing monotonic function of distance. A simpler model (Kelker 1945) assumes $P_x = 1$ for all observations within a threshold distance D' , beyond which animals are missed, and $P_x = 0$ thereafter.

Density estimates are:

(1) Eberhardt $$\hat{D} = \frac{n(1000)}{2 \cdot \bar{X} \cdot L} \left[\frac{(K+1)^2}{2K\ (K+2)}\right]$$

(2) Kelker $$\hat{D} = \frac{n'\ (1000)}{2 \cdot D' \cdot L}$$

where $\hat{D}$ = density estimate, number/Km^2

N = number seen during census

n'= number seen within distance D'

D'= threshold distance beyond which observability decreases, m

$\bar{X}$ = mean distance, m

L = length of transect, Km

K = constant from the form of observability curve

1,000 = constant from L in Km,
$\overline{X}$ (n') in meters,

2 = constant, two sides of census route

Five different mark-recapture techniques were used to estimate population size. Four of the methods are based upon the Petersen estimate (= Lincoln Index) including: (1) Schnabel estimate (Schnabel 1938); (2) Schnabel estimate, Overton modification, which allows for known mortality; (3) Schumacher-Eschmeyer estimate (Schumacher and Eschmeyer 1943), which allows for variable catchability; (4) Jolly-Seber method (Jolly 1965; Seber 1965; Caughley 1977), which allows for known mortality as well as immigration, and provides a stochastic estimate of population size. In addition, the Edwards and Eberhardt estimate (Edwards and Eberhardt 1967) was used, which is based upon frequency of capture and allows catchability.

Mark-recapture techniques, their formulas, and advantages of each are listed in Table 1. Further comparisons are found in Caughley (1977) and Giles (1969).

Number of belled and unbelled animals observed both during night census and at blinds were subjected to the Schnabel method (Schnabel 1938) for two additional population estimations.

Table 1. Mark-recapture techniques used to estimate wild boar density on Spence Field study area, 1977

Technique	Formula[1/]	Allowable Variations		
		Variable Catchability	Mortality	Change in Population Size
1. Schnabel	$\hat{N} = \frac{\Sigma M_\imath N_\imath}{\Sigma X_\imath}$			
2. Schnabel with Overton modification	$\hat{N} = \frac{\Sigma M_\imath N_\imath}{\Sigma X_\imath} + \left(\frac{1}{\Sigma X_\imath}\right) \Sigma \frac{N_\imath M_\imath}{\hat{N} - Z_\imath}$			
3. Schumacher-Eschmeyer	$\hat{N} = \frac{\Sigma M_\imath^2 N_\imath}{\Sigma M_\imath X_i}$			
4. Jolly-Seber	$\hat{N} = N + \frac{N_\imath S_\imath R_\imath}{X_\imath P_\imath}$			
5. Edwards-Eberhardt	$\hat{N} = \frac{C}{1 - C/_T}$			

[1/] Explanation of all symbols:

$\hat{N}$ = population estimate.

$M_\imath$ = Number of animals marked prior to $\imath^{th}$ occasion.

$N_\imath$ = Number of animals captured during $\imath^{th}$ occasion.

$X_\imath$ = Number of marked animals recaptured at $\imath^{th}$ occasion.

$S_\imath$ = Number marked prior to $\imath^{th}$ occasion, not recaptured at $\imath$ but subsequently recaptured.

R_ι = Number of animals marked and released during ι^{th} occasion.

P_ι = Number of animals of the R released during ι and subsequently recaptured.

C = Number of individual animals captured.

T = Total number of captures.

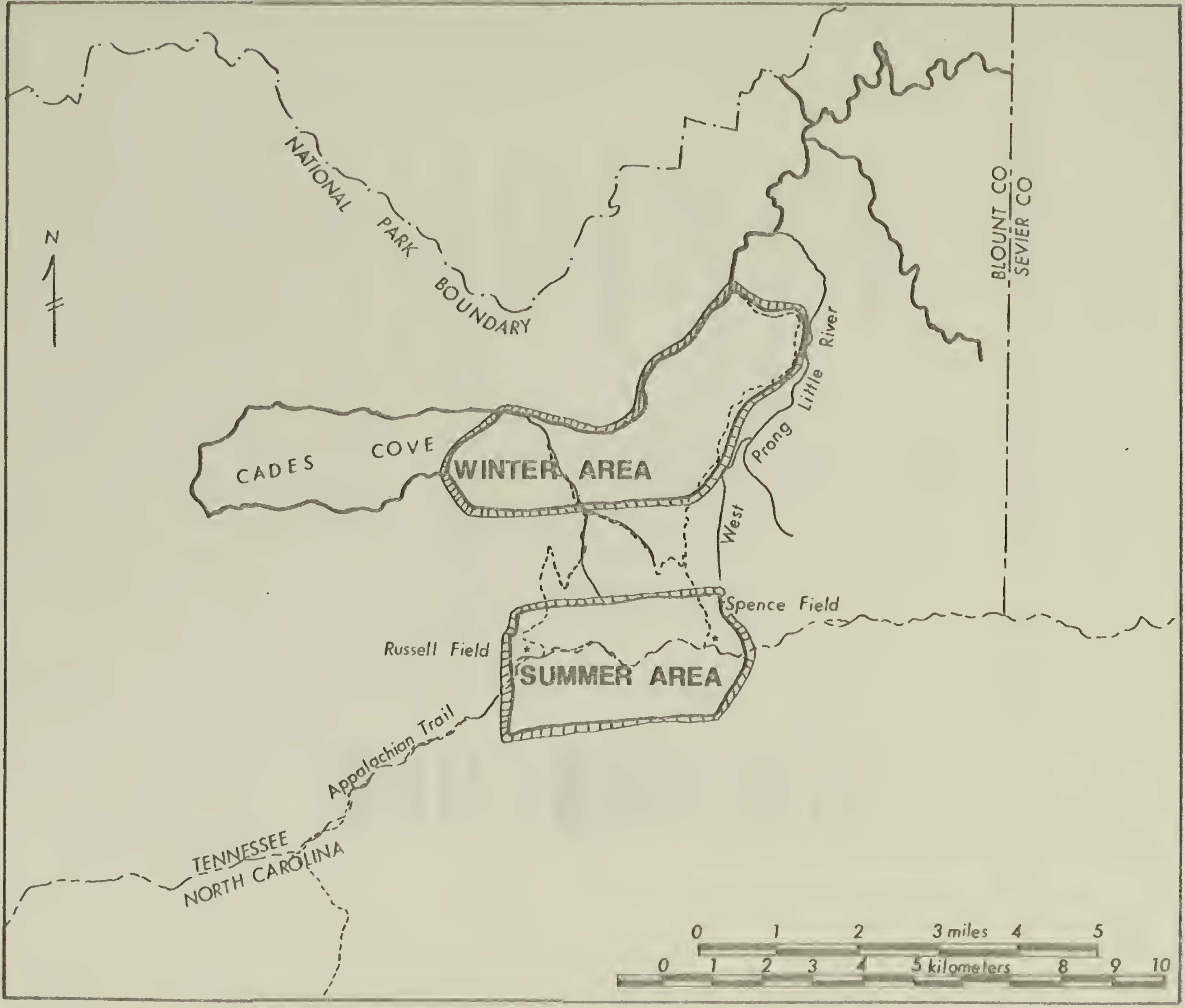
STUDY AREA

A valley area near Cades Cove was trapped during winter (456-812 meters) and a ridgeline peak area at Spence Field during spring/summer (1,116 - 1,287 meters), while data was gathered on many animals from Gregory Bald taken in the park's management program (Figure 1). Vegetation is described by Shanks (1954) and Whittaker (1956). Precipitation ranges from 127 centimeters per year at park headquarters to approximately 229 centimeters per year at the mountain peaks. The ridgeline peak generally has some winter snow cover, with accumulations of one meter from December to February in the winter of 1976-77.

Forest Types

Ten major forest types were recognized for the ridgeline peak study area and are mapped in Figure 2. Rhododendron understories (*Rhododenron maximum* and *Kalmia latifolia*) greater than 75 percent cover are mapped in Figure 3.

Figure 1. Map of winter and summer study areas, 1977.


NATIONAL PARK BOUNDARY
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SEVIER CO
N
Little River
Prong
West
CADES COVE
WINTER AREA
SUMMER AREA
Spence Field
Russell Field
Appalachian Trail
TENNESSEE
NORTH CAROLINA
0 1 2 3 miles 4 5
0 1 2 3 4 5 kilometers 8 9 10

Figure 2. Map of 10 forest types on the Spence Field study area.

KEY

Forest Type	Symbol
Gray Beech	▒
Northern Hardwoods	≋
Hemlock Hardwoods	░
Black Birch - Rhododendron	≈
Cove Hardwoods	▥
Heath Bald	■
Grassy Bald	□
Red Maple - Sourwood - Rhododendron	✚
Oak - Red Maple	⫽
Chestnut Oak - Rhododendron	▨

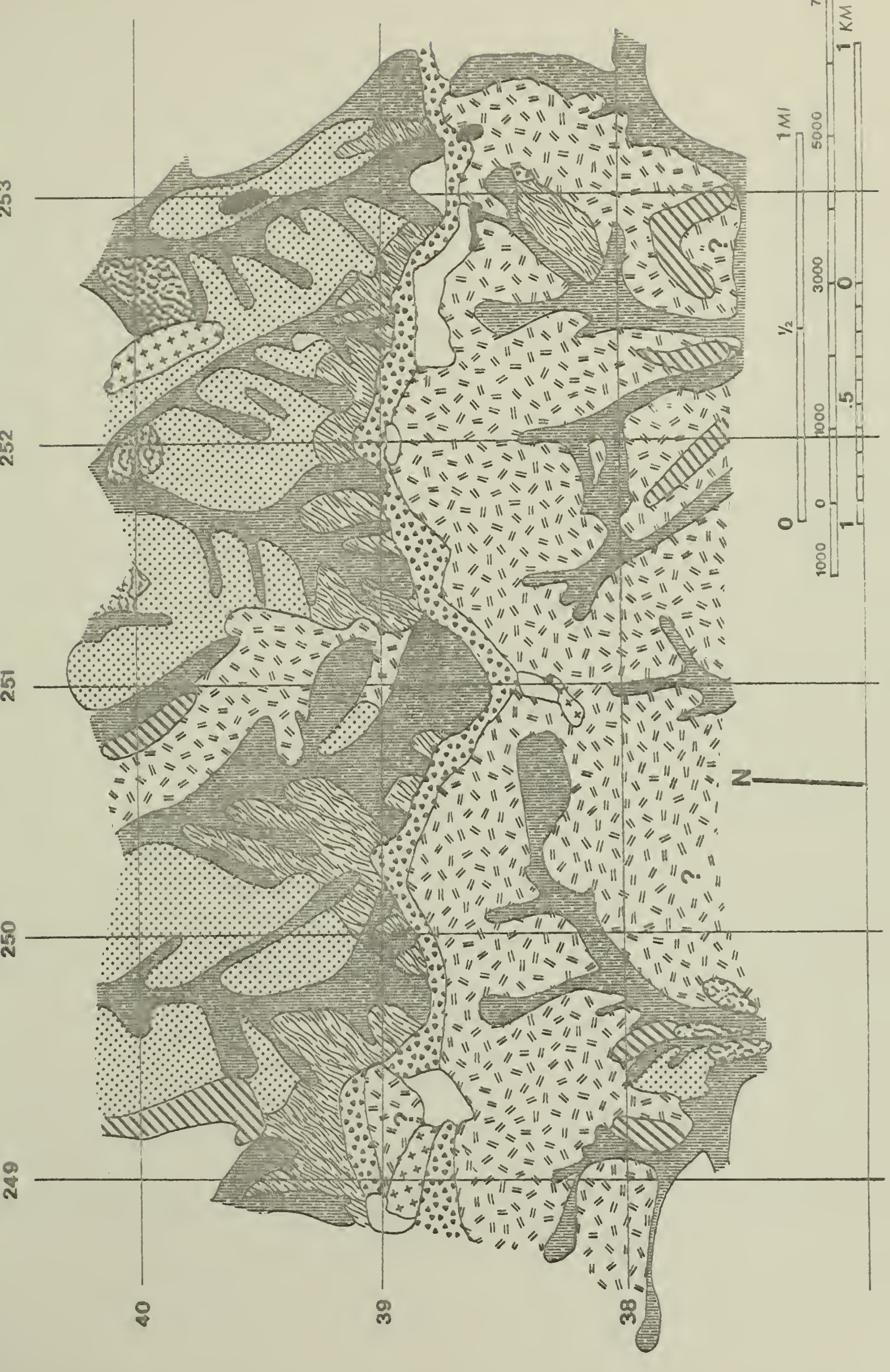
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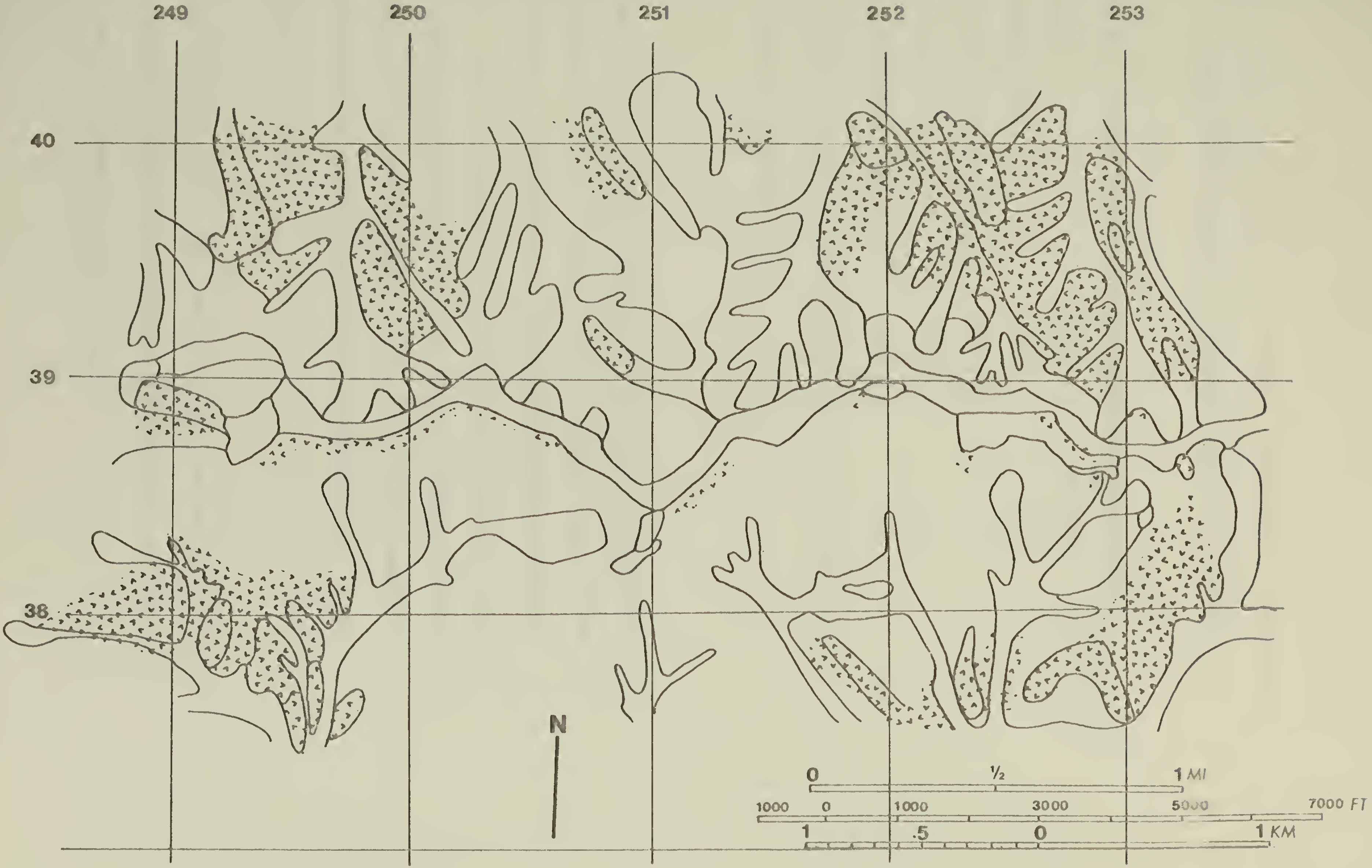
Figure 3. Map of rhododendron understory (>75 percent) on the Spence Field study area.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1 KM

Trap success was higher in the present backcountry study than for previous park trapping conducted along roads (Table 2).

Table 2. Comparisons between different trap programs.

Group	Year	No. animals	Trap nights per animal
Present study	1977	32	14.0
Bud Philips (NPS)[1]	1971-72	52	22.0
Ron Fox [1]	1971-72	70	47.5
National Park Service [1]	1965-72	213	73.6

[1] Figures from Fox (1972)

Many escapes occurred (Table 3), including 23 instances of lifting the door, 18 instances of breaking through sides of the trap, 11 cases when the trigger failed to release, and 3 cases of piglets squeezing out. Wild boar apparently learned to lift doors, since we did not observe lifting until the 24th trap day; lifting of doors was very common by the 29th day. We actually observed two animals, both sows, lift doors and escape.

Wild boar were wary of entering traps. Animals took bait outside or right at the door of traps without entering, 62 times (.96 times for every capture).

Location along the ridgeline of the eight traps apparently did not affect their success. The only exception was one trap located next to a feeding station where 21 (33 percent) captures were made. Both door designs were intermixed along the trap line, yet significantly greater total activity and higher capture success were experienced in the swing style doors than the guillotine style doors ($\chi^2 = 8.42 > 3.84$, $P < .05$) (Table 3).

Table 3. Comparison of door designs, Spence Field study area.

	Door Design	
	Swing	Guillotine
No. captures	45	13
No. escapes	29	27
TOTAL	74	40

No multiple-entry into traps with the swing-style doors was verified. Possibilities for multiple-entry were limited since captured animals rooted the doors shut, and since we attached catches to reduce the lifting of doors.

Black bears disrupted our trapping and feeding station efforts during summer. Bears sprung traps 33 times, removed bait, and may have caused swine to avoid the baits. Bears killed

one piglet in a trap and attacked a male yearling wild boar in another. We terminated feeding stations after July 31 due to the bear activity.

Shooting

Fourteen wild boar were removed east of the Spence Field study area, a yield of one hog per 4.9 man-hours of hunting (Table 4), or about the same as the trapping yield (one hog per 4.3 man-hours of trapping). An average of 0.93 wild boar were taken per night of trapping.

Table 4. Summary of 14 nights of shooting along the ridgeline peak, 1977

	Man Hours	No. Boar Shot	No. Boar Observed	No. Kilometers Hiked
Total	68.5	14	87	50.9
Mean per night	4.6	0.93	5.8	3.4
Range	2.5-7.0	0-3	0-17	1-9.5
Standard Deviation		.26	1.25	

Due to thick understories, it was difficult to get a clear shot by flashlight, and as a result, only one wild boar was harvested per 6.2 observed. In addition, increased wariness

was observed on the Spence Field study area, where more human disturbances from the research teams occurred. More groups of animals were flushed in this area, 16 (55 percent), versus 6 (10 percent) off of the area. Large groups may have been broken up since we observed fewer large groups than Shaffer (1978) did in the same area the previous year and average group size was 1.20 versus 1.87 off of the Spence Field study area.

Feeding Stations

Feeding stations were manned for 18 nights by eight different observers. A minimum of 13 different animals used one feeder on two nights during June, the other feeder was used by fewer animals. One wild boar visited the stations for every 1.0 hour of observation (Table 5).

Table 5. Wild boar activity at feeding stations, 1977

	Total Boar	No. Adults	No. Piglets	No. Boar with bells	No. Hours of observation
Total for 18 nights	49	45	4	18	48.5
Average per night	2.7	2.5	0.2	1.0	2.7
Range	0-9	0-6	0-3	0-3	0.2-5.0

Movements

Wild boar first occupied and rooted the ridgeline peak study area in early April (first observation, April 9) and remained in numbers until early August. Movements of marked animals off the ridgeline began August 2 (Figure 4) and continued until the peaks were vacated by early September.

Average width of summer home ranges of European wild boar (April to July), as determined by recapture or observations of marked animals, was greater for males (n = 4 males) than for females (n = 5 females) (Figure 5). The differences between sexes was not significantly different ($P < .05$) and therefore, the home range size was pooled, 0.81 Km $\leq$ width of summer range $\leq$ 1.51 Km (95 percent confidence intervals).

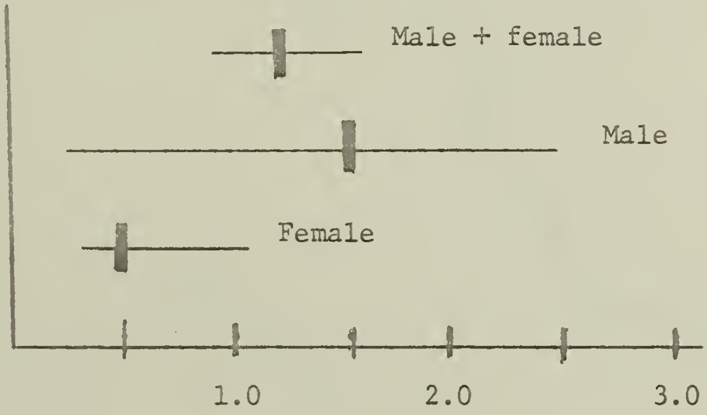
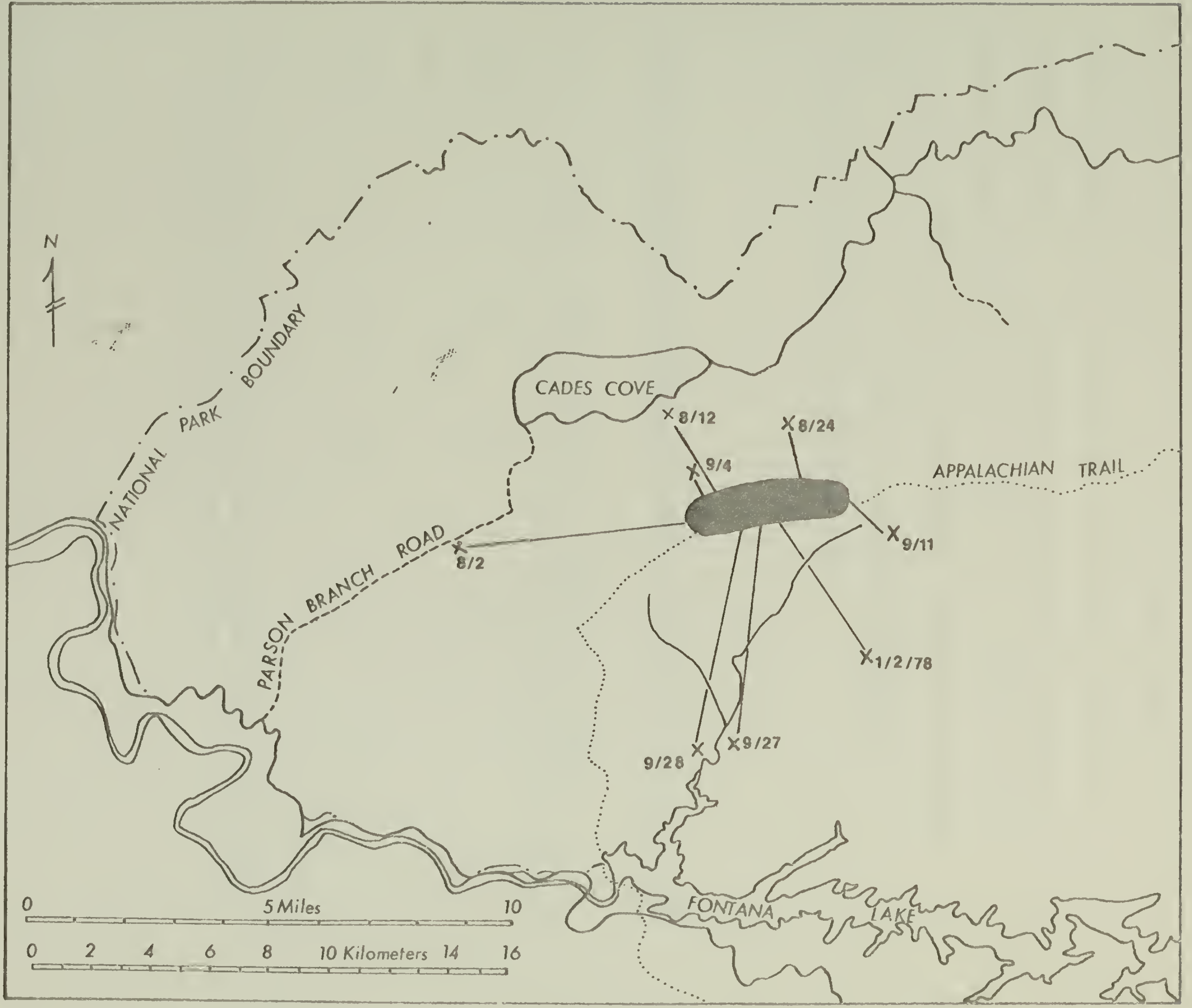


Figure 5. Linear width along ridgeline of summer observations (retrapping and observations) of marked individuals, 1977.

the Ridgeline Study area, 1977.


N
NATIONAL PARK BOUNDARY
CADES COVE
X 8/12
X 8/24
X 9/4
APPALACHIAN TRAIL
X 9/11
PARSON BRANCH ROAD
X 8/2
X 1/2/78
X 9/27
X 9/28
FONTANA LAKE
0
5 Miles
10
0
2
4
6
8
10 Kilometers
14
16

Reproduction

A total of 56 sows over six months of age were captured, of which a minimum of 25 (46 percent) were either lactating or pregnant (Table 6). Information on another nine litters was gathered through collection of piglets only. Numbers of sows breeding in summer was not significantly different from winter ($\chi^2_{df=1} = .34 < 3.84$, $P < .05$). We could not determine reproductive status of live-captured sows.

Table 6. Reproductive status of 56 sows.

Season	TOTAL	No. Barren	No. Pregnant	No. Lactating	No. Unknown [1]
Summer	47	22	11	10	4
Winter	9	3	1	4	1
TOTAL	56	25	12	14	5

[1] These animals were live-captured and released, and it could not be determined if they were pregnant or barren.

Two apparent farrowing peaks were observed, one in December-January and one in April-June (n = 26 litters) similar to peaks observed by Conley et al. (1972) elsewhere in the southern Appalachians (Figure 6).

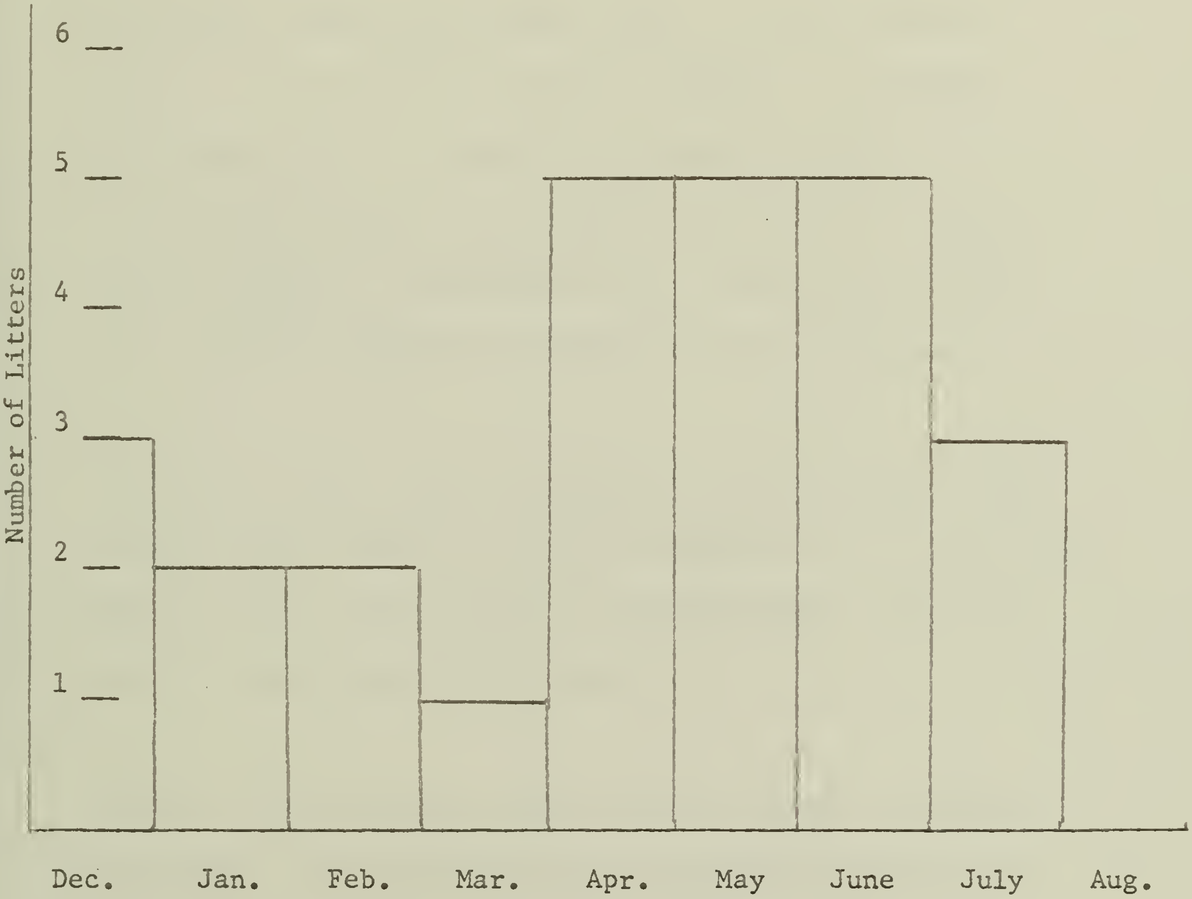


Figure 6 . Farrowing dates computed by estimated birth date of fetuses (n = 12 litters) and backdated birth date of piglets (n = 14 litters).

Pre-natal litter size ranged from 3 to 7 and averaged 4.75 ± 0.70 (95 percent confidence interval) for 12 sows. Henry (1966) found fetuses numbering 4 to 5 per litter elsewhere in the southern Appalachians.

Post-natal litter sizes ranged from 1 to 5 and averaged 3.03 ± .50 (95 percent confidence limits). We combined trap samples (n = 23 litters) and field observations (n = 7 litters), since the two values were identical. Duncan (1974) reported 3.5 piglets/sow (n = 6 sows) while Conley et al. (1972) reported an average of 4.2 (n = 28 sows).

Comparison between pre- and post-natal litter counts suggest minimum piglet losses of 1.71 (36 percent) in the first four months of life. This figure is underestimated since some loss of entire litters must occur.

Numbers of unclassified piglets were too large to estimate sex ratios. We presumed equal sex ratios based upon work in the park in 1971-72 for litters (Duncan 1974) and for all age classes taken in the control program, 1959-75 (Singer 1976).

One sow (Radio No. 12) was observed to breed twice in one year (April 27-28, 1977, and January 1-7, 1978), eight and one-half months apart, producing 4 and 6 piglets, respectively. A second sow (UP. 18), age 5 years, was also suspected of

producing litters six to eight months apart.

Only sows over one year old were found with piglets. Breeding in young sows (1 to 2 years old) was 43 percent (n = 14 sows), but for older sows (n = 13 sows) was 69 percent; however, these differences were not significant ($\chi^2_{df=1} = 1.85 < 3.84, P < .05$). Caughley (1977) reported that in many control programs, shooting is biased towards older (and larger) animals. In addition, older and more dominant animals might enter traps first and bias trap data against piglets. Litter sizes were identical between trap and field observations and piglet ratios were not significantly different ($\chi_{df = 1} = 2.34 < 3.84, P < .05$). Shot and trap samples were not different $\chi^2_{df=1} = 0.99 < 3.84, P < .05$).

Group Dynamics

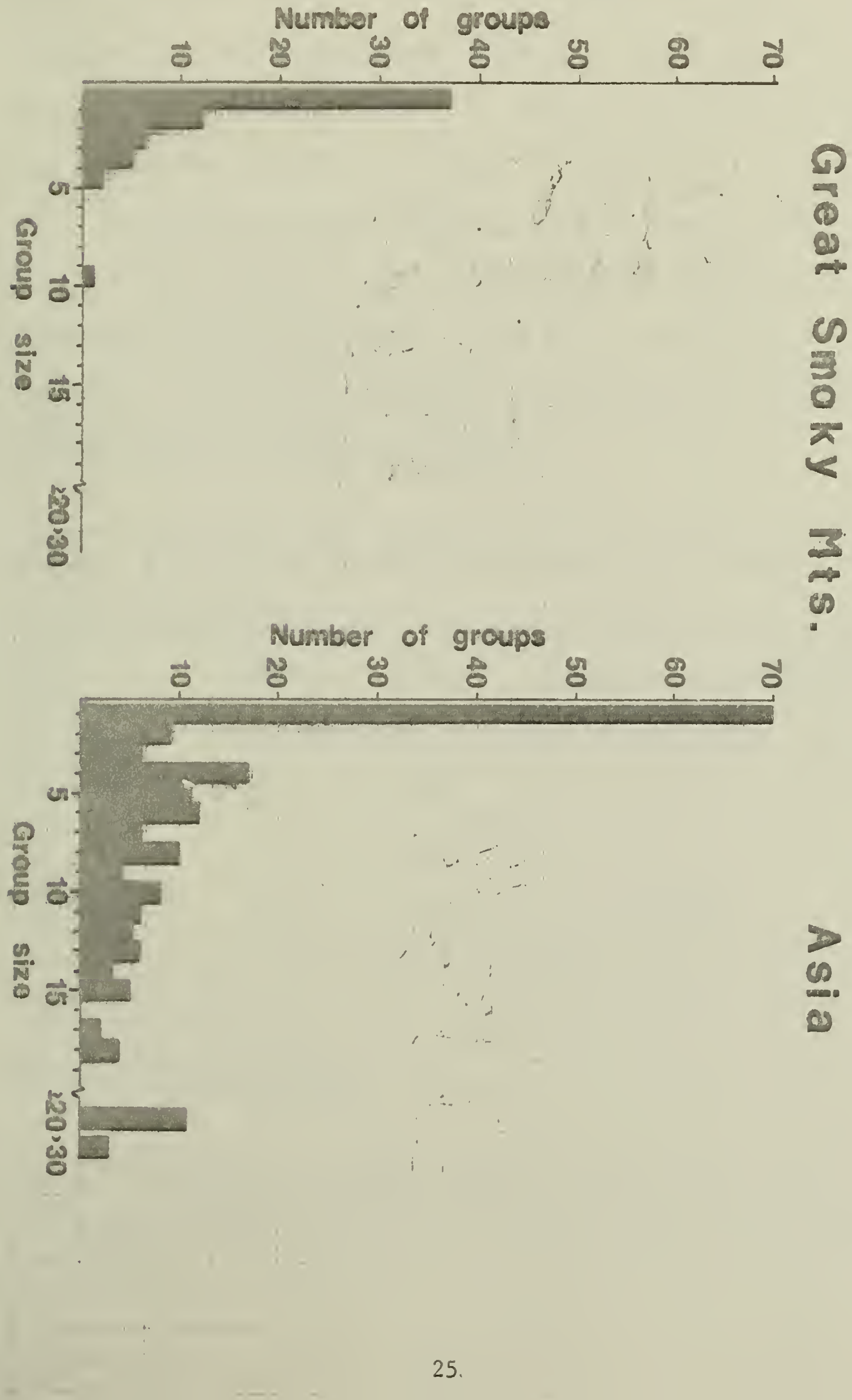
Average group size was 1.87 ± 0.64 (95 percent confidence interval). Most groupings were sows and young (Table 7, as Conley et al. (1972) and Shaffer (1978) observed. Yearlings (8 to 14 months) were found alone, with sows, or with other yearlings. One pair of yearlings were known to be siblings. In striking contrast to wild boar on native ranges (Sludskii

1955; Eisenberg and Lockhardt 1972), no "sounders" or large groups of sows with even-aged young were observed, nor were most solitary animals adult males (see Figure 7). In the present study, solitary animals included 20 (23 percent) adult sows, 15 (17 percent) adult males, 14 (16 percent) yearlings, and 37 (43 percent) unclassified.

Table 7 . Groupings of wild boar, Spence Field, 1977

Group Type	Number in Group 1	2	3	4	5	9	TOTAL
Yearlings	8	5					13
Sows	8						8
Boars	5						5
Unclassified adult	16	5	4	1			26
Family		2	1	2	1		6
Extended family			1	2	1		4
Multiple family							0
Mixed						1	1
	37	12	6	5	2	1	63

Figure 7. Grouping tendency for European wild boar in the present Southern Appalachian study and an Asian area (Eisenberg and Lockhardt 1972).



Significantly more adult sows were found in the summer in the ridgeline population (Table 8) than in the valley areas ($\chi^2_{df=2} = 21.65 > 7.81, P <.05$). We combined all summer ridgeline data since sex ratios of adults (> 14 months old) were not ignificantly different in trap and field census samples. from Spence Field study area ($\chi^2_{df=1} = 2.86 < 3.84, P < .05$) or for trap samples between Spence Field and Gregory Bald areas ($\chi^2_{df=1} = 2.80 > 3.84, P< .05$). Shaffer (1978) reported more sows at Spence Field in the summer of 1976 than he observed in Cades Cove. Also, Fox and Pelton (1978) trapped a preponderance of adult males in Cades Cove, 1971-72.

Table 8. Differential distribution of adult sex classes, summer 1977.

Area	Males	Sows	Male : 1.00 Female
Ridgeline	19	52	.36
Valley floor	20	5	4.00

Condition and Distribution

Only 12 (9 percent) of animals rated (n = 127) were in poor condition, including 3 adult and 1 sub-adult male, 5 lactating

sows and 4 small (< 6 months old) piglets. Good condition was expected, since mast production was good in 1976.

Eisenberg and Lockhardt (1972) suggest that independent foraging by adult males and female ungulates reduces direct competition. We hypothesized that the ridgeline peak area supported more abundant food resources and that is why, in summer, more gestating and lactating females inhabited the area. The corollary was that food resources at lower elevations were poor and more dispersed. More males were found in poor condition at the lower elevations (Table 9), but the difference was not significant ($P < 0.05$).

Table 9. Number of males found in poor condition at the ridgetop (elevations > 1,218 meters) and the valleys, spring-summer 1977.

Area	Collected	Poor Condition
Ridgetop	21	0
Valleys	18	3

More lactating sows and suckling piglets were rated in poor condition than other classes. All pregnant (n = 12) and all but one non-breeding (n = 25) sows were in good/excellent condition. There was no difference in condition of litters between the two breeding areas and seasons in 1976-77 (Table 10).

Table 10. Numbers of litters with either a lactating sow or suckling piglet in poor condition.

Area (Season)	Total litters	No. litters with one or more animals in poor condition
Ridgetop (Summer)	17	7
Valleys (Winter)	3	1

Population Estimates — Mark-Recapture

Caughley (1977;134) stated that, "mark-recapture analyses are not particularly robust and small deviations from their implicit assumptions can produce large errors in the results." Catchability was not equal for all animals in our trapping study ($\chi^2 = 53.0, 40.0$ $P > 0.05$). As a result, all estimates using mark-recapture data (Table 12) are underestimated and invalid. In addition, the estimate from belled animals along night census (Table) although it does not involve catchability, is also underestimated, since belled animals were easier to detect than unbelled.

Table 11. Best estimates of population size for the ridgetop study area, 1977, using mark-recapture techniques.

Estimator	Population estimate, eastern half of study area	Population estimate, study area
MARK/RECAPTURE - Ridgeline population only		
Trap Data:		
(1) Schnabel with Overton modification		33.2
(2) Schumacher-Eschmeyer		34.9
(3) Edwards-Eberhardt		63
Feeding Station Observations		
(4) Schnabel (belled; unbelled)	17.8	(χ2.08 = 37.1)
Night Census Observations:		
(5) Schnabel (belled; unbelled	29.6	(χ2.08 = 61.6)

Population Estimates - Strip Census

Twenty-five night censuses were conducted between May 14 and August 1. A total of 72.3 kilometers was censused, and a total 157 observations of wild boar were made ($\bar{\chi}$ = 2.17 observations/kilometers hiked). We censused the area from Mollies Ridge to Beechnut Gap (12.6 kilometers) along the Appalachian Trail and 1 to 2 kilometers down four side trails.

Our strip census met the basic assumptions (Seber 1973) and are believed to be more valid than any of the mark-recapture estimates. Estimated density of wild boar/square kilometer are provided in Table 12 for each vegetation type. We grouped

Table 12. Vegetation types and wild boar observed along census trails in the Spence Field study area, 1977.

Forest 1 type	Percent rooted	Area (hectares)	Grouped area (hectares)	Distance censused (kilometers)	No. observations: Total area	No. observations: (Spence Field area only)	Density (square kilometers: Total Area (Spence only): Eberhardt	Density (square kilometers: Total Area (Spence only): Kelker
Gray Beech	100	55	150	5.5	80	(23)	70.6 (72)	50.9 (67.9)
Northern hardwoods	60	95						
Red maple-sourwood-heath	0	13	438	12.4	44	(44)	87 (87)	82.4 (82.4)
Oak-red maple	0	425						
Hemlock hardwoods	0	64	555	2.9	0	(0)	0 (0)	0 (0)
Cove	25	245						
Heath Understory:								
Chestnut oak-heath	0	33						
Heath bald	0	2						
Hemlock hardwood	0	115						
Oak-red maple	0	53						
Cove hardwoods	0	24						
Black birch-heath	0	19						
Grassy bald	0	17	17	14.4	16	(7)	-- --	17.9 (12)
TOTAL			1,160 hectares	35.3	140	(74)		

all census observations, correcting for the amounts of each forest type available. We arrived at the estimate of 86.2 (Kelker 1945) - 92.0 (Eberhardt 1968) wild boar on the Spence Field study area, or 17.6 - 18.8 wild boar per linear kilometer of ridgeline based on our limited sample to date.

Harvesting of Ridgeline Population

Our goal is to gather enough data to predict what effect different harvest levels will have upon the population. The data matrix will be complex and will warrant future computer modeling. In order to direct our field investigations we attempted a preliminary simulation of harvests, using a model described in detail by Tipton (in press). Our only modifications of Tipton's model were to use our own data on percent of females breeding, litter sizes, and preliminary survival rates. Population simulation of three different preliminary harvesting strategies are diagrammed in Figures 8, 9, and 10. We assumed a ridgeline population of 700 for illustrative purposes based upon number of boar per linear kilometer of ridgeline).

The simulations suggest that winter and summer harvests are nearly equal in effect, and that a single 50 percent harvest has a much greater effect than two harvests of 25 percent each. The preliminary simulations suggest several areas where data is needed to improve predictability.

Figure 8. Comparison of population responses to a 50 percent harvest under a variety of mast conditions. (AB = abundant; FL = failure; FR = fair)

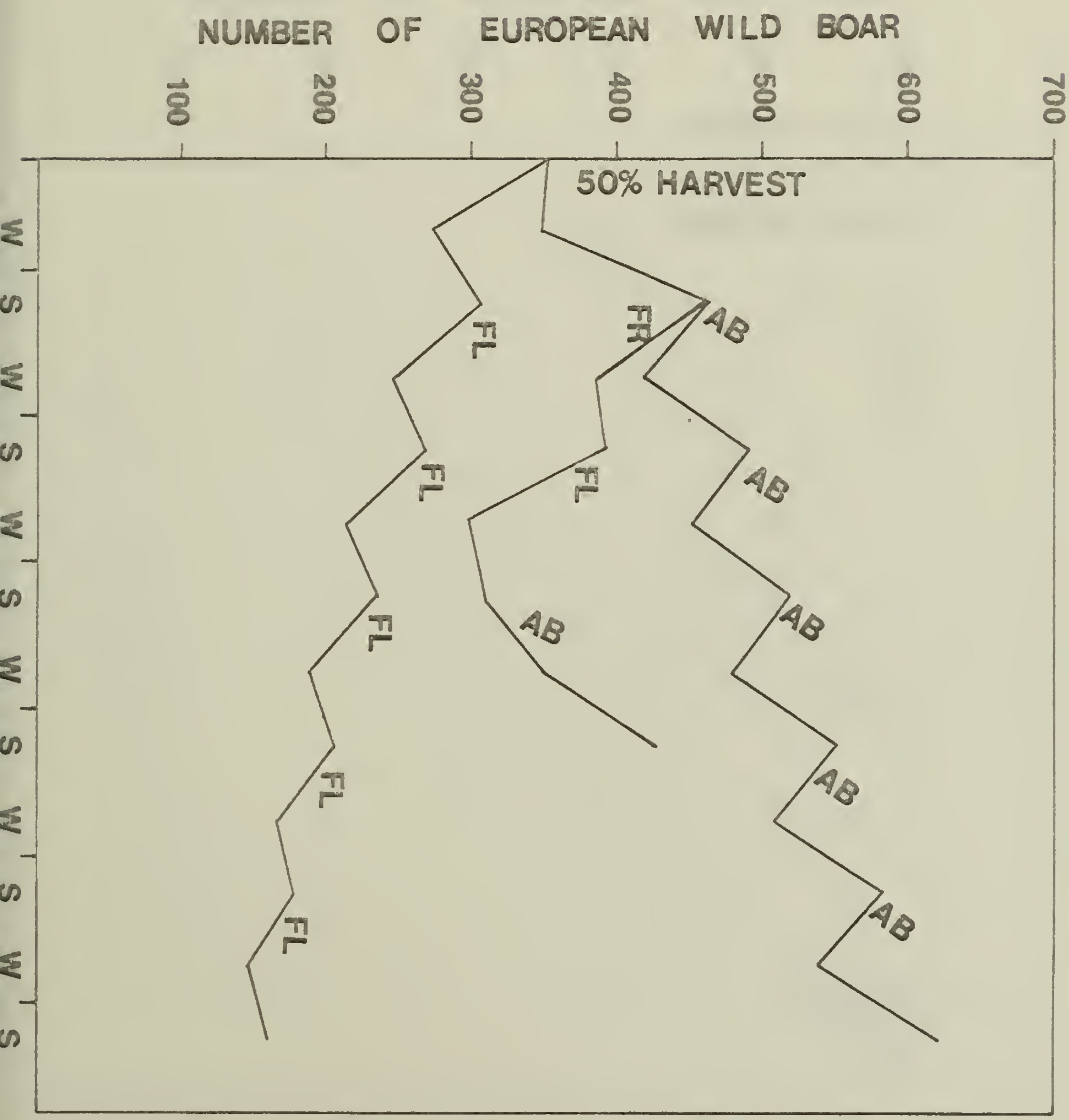


Figure 9. Comparison of population response to summer and winter harvests and harvests of 25 and 50 percent.

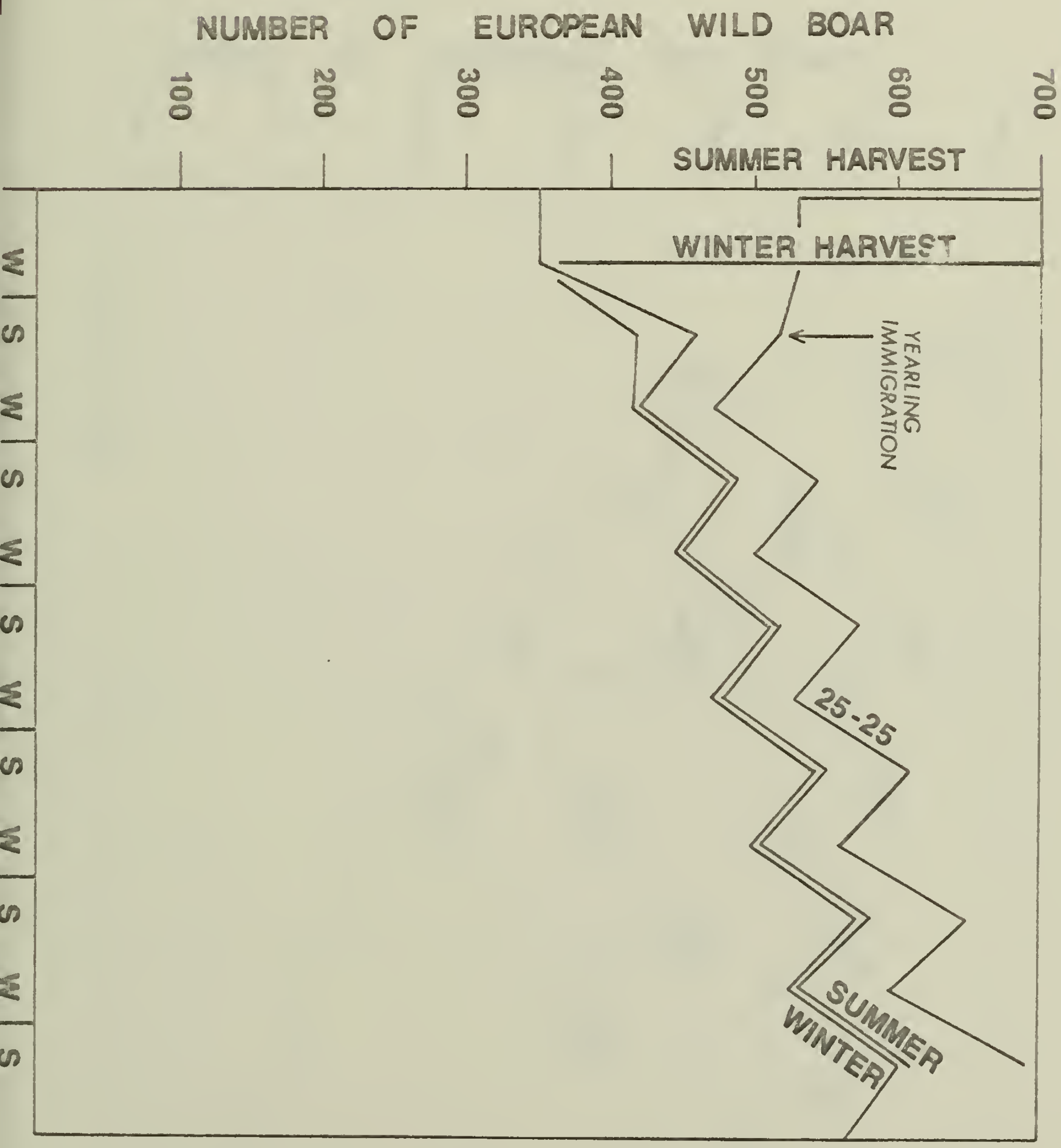
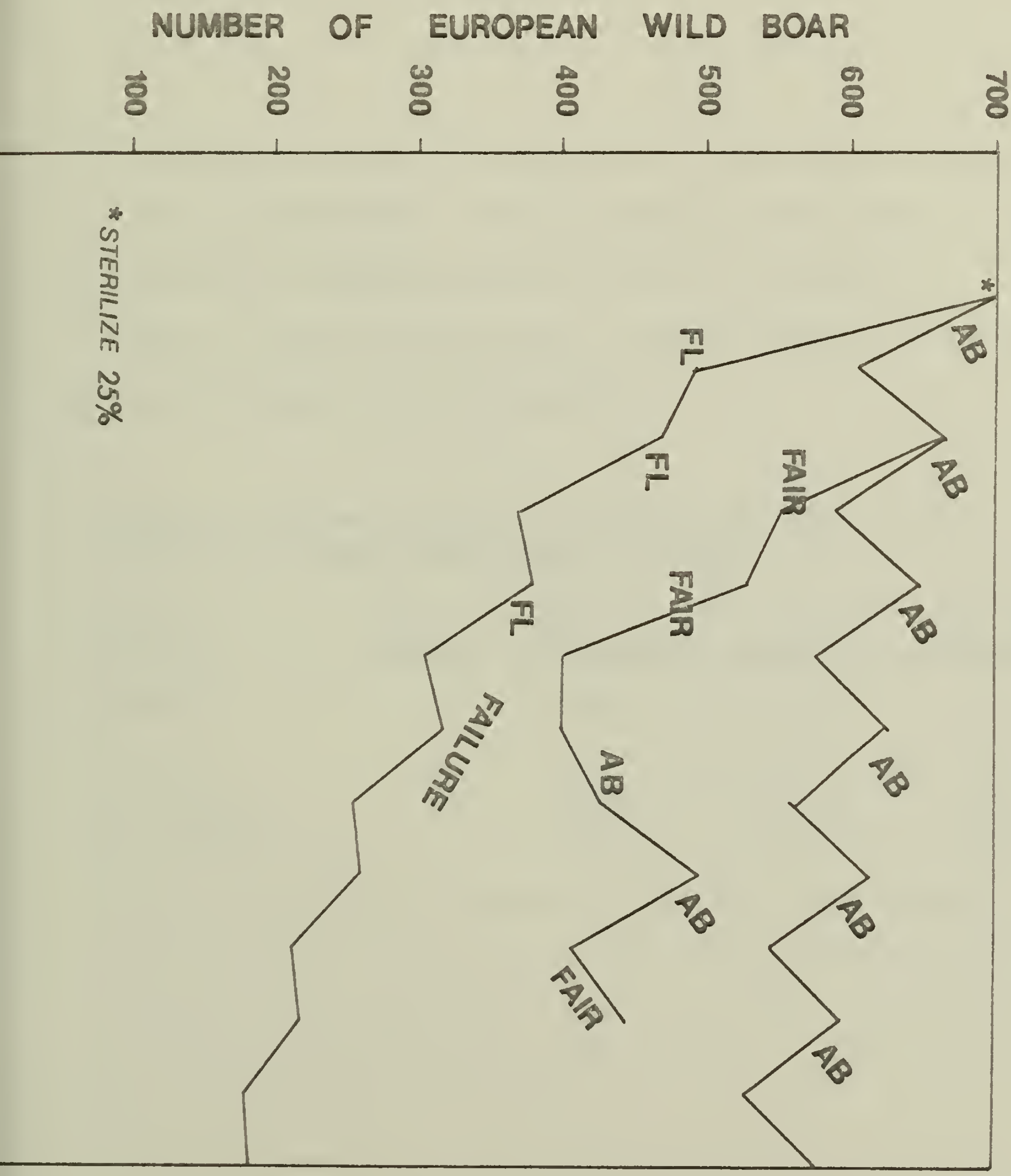


Figure 10. Simulated population response to sterilization of 25 percent of the females in the ridgeline population under a variety of mast conditions.



These are: (1) more accurate aging of adults; (2) knowledge of compensatory mechanisms; (3) more data on winter breeding; (4) behavioral and population response to any sterilization (5) census data from a larger area.

The effort to harvest 50 percent of the ridgeline population would be considerable. For the Tennessee control team, it required 53.3 man-hours in winter and 20.4 man-hours in summer to collect one wild boar, although success has been as high as 10.8 manhours for one individual.

Table 13. Harvest success of the Tennessee control team, 1976, 1977. (Crew varied from 1 to 4 men.)

Period	No. months	No. man-hours	No. wild boar	Man-hours/ hog taken
Nov-Mar	5	1,120	21	53.3
Apr-July	4	1,040	51	20.4
(F. Branam)		(400)	(37)	(10.8)

One man worked for ten weeks in a ridgeline peak area harvesting 32 wild boar in a small area (3.2 kilometer ridgeline) and 40 wild boar in a larger area (6 4 kilometer ridgeline). The length of the western ridgeline in the park dominated by hardwoods is 48.1 kilometers or 7.5 to 15 times the area harvested by this individual. In addition, this individual was the most effective case. Obviously, more effective harvest techniques are needed.

DISCUSSION

Research in 1978

1. Mast production. Mast survey will be expanded in 1978.

2. Trapping. Soil damage and repeated escapes were problems in 1977. Traps in 1978 will be portable and be made of steel tubing and cyclone fencing to eliminate the constant repairs and escapes. Etorphine-hydrochloride (M_{99}) or Rompun-Ketaset will be used as immobolizing drugs in 1978 in order to reduce injuries and deaths from handling.

3. Census--Mark/Recapture. Mark-recapture techniques were invalid due to unequal catchability between animals and are not recommended for future use. Greater validity might be

achieved by increasing sample sizes to 10 animals per trap session and by reducing differential catchability by relocation of traps. The effort and cost of more captures required, however, may not be justified.

Census-Strip Census. Grouping all strip censuses was necessary with our data. However, it was not possible to estimate the precision of the technique. Longer censuses on standard trails and at regular intervals must be accomplished. More samples in a greater diversity of habitats would improve extrapolations to larger areas. Radial distance to the observed animal should be recorded in addition to perpendicular distance from census line to the animal. Then the King-Strip Census method (Robinette et al. 1974) could be used, which provides a better estimate of maximum distance at which animals can be observed. Longer censuses of about 20 kilometers would enable use of the Hanson plot removal technique (Hanson 1968), where 20 plots of about the size of home range diameter (1 kilometer) are needed (D. Urbston personal corres.) Longer census lines will require three or more people working different trail sections in the same evening.

4. Home Ranges/Seasonal Movements. More information is needed on seasonal movements and home ranges. Records are available for only 7 to 8 months per animal. Methods will be the same

as in 1977 (Otto , D. 1977, Thesis Working Plan, Virginia Polytechnic Institute and State University).

5. Population Dynamics/Compensatory Mechanisms. Information is needed on response of the population to heavy harvesting. This can be accomplished by investigating population characteristics in the Gregory Bald area one year after heavy harvest (estimated 33-53 percent) using Spence Field area as a control. About 35 animals need to be sexed, aged, and have reproductive status for sows determined in each area. Either live or dead animals could be used.

6. Condition of wild boar was subjectively estimated in 1977. In 1978, we propose to measure (1) depth of backfat; (2) depth of stomach fat; (3) kidney fat ratio; (4) weight of stomach contents; (5) quality of key forages; (6) serum blood values: serum protein, serum urea, and serum albumin/globulin. W. J. Cook will analyze blood samples. Blood samples can be taken from either live or freshly killed animals.

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APPENDIX

PART I

Table 1. Predominant trees (t) and shrubs (s) in each forest type.

	Northern Hardwoods	Hardwoods	Hemlock Hardwoods	Black Birch Heath	Cove Hardwoods	Heath Bald	Grassy Bald	Med Maple Sourwood	Oak Red Maple	Chestnut Oak-Heath	Beech Birch Sedge
Fagus grandifolia	ts	ts	t						ts		ts
Betula lutea	ts	t			ts						ts
Amelanchier laevis	ts						ts	ts	ts	ts	
Aesculus octandra	ts				ts						
Halesia carolina		t	ts							ts	
Acer saccharum		ts			s						
Acer pensylvanicum		ts									
Prunus serotina		t									
Viburnum alnifolium		s	s		s						
Tsuga canadensis			ts	s	t						
Acer rubrum			t				ts	ts	ts	ts	
Magnolia fraseri			ts	t							
Betula lenta				ts							

Table 1. Predominant trees (t) and shrubs (s) in each forest type - Cont.

	Northern Hardwoods	Hardwoods	Hemlock Hardwoods	Black Birch Heath	Cove Hardwoods	Heath Bald	Grassy Bald	Red Maple Sourwood	Oak Red Maple	Chestnut Oak-Heath	Beech Birch Sedge
Rhododendron maximum			s		s	s		s		s	
Tilia heterophylla					ts						
Fraxinus americana					ts						
Liriodendron tulipifera					t						
Acer spicatum					s						
Hydrangea arborescens					s						
Euonymus americanus					s						
Kalmia latifolia						s		s		s	
Prunus pensylvanica						s					
Pyrus americana						s					
Quercus rubra							ts	ts	ts	ts	
Oxydendrum arboreum								ts		ts	
Quercus alba									ts		

Table 1. Predominant trees (t) and shrubs (s) in each forest type - Cont.

	Northern Hardwoods	Hardwoods	Hemlock Hardwoods	Black Birch Heath	Cove Hardwoods	Heath Bald	Grassy Bald	Red Maple Sourwood	Oak Red Maple	Chestnut Oak-Heath	Beech Birch Sedge
Quercus prinus										ts	
Magnolia acuminata									ts		
Rhododendron calandulaceum									s		
Castanea dentata									s		
Vaccinium sp.							s		s		
Ilex montana									s		
Pinus pungens								t			

Table 2. Length of Forest Types Along Hog Census Trails

		Meters	Percent Availability
Northern Hardwoods		3,275	25.8
Hardwoods		0	0.0
Hemlock Hardwoods:			
a) with Rhododendron understory*		150	1.2
b) without Rhododendron understory		0	0.0
Black Birch-Heath*		0	0.0
Cove Hardwoods:			
a) with Rhododendron understory*		0	0.0
b) without Rhododendron understory		1,175	9.3
Heath Bald*		150	1.2
Grassy Bald		2,025	16.0
Beech-Birch-Sedge:			
a) with Rhododendron		500	3.9
b) without Rhododendron		500	3.9
Red Maple-Sourwood-Heath*		475	3.7
Oak-Red Maple:			
a) with Rhododendron understory*		925	7.3
b) without Rhododendron understory		3,500	27.6
Chestnut Oak-Heath*		0	0.0
Sub-Totals	(*)	2,200	17.4
Without		10,475	82.6
TOTALS		12,675	100.0

Table 3. Summary of trapping program, November 1976 - September 1977; Work effort, captures, and success.

Month	No. traps set	Trap nights	No. pigs	Trap nights/ pig	Escapes	Took bait beyond capture and escape	Within 30 meters of trap	Black bears	White-tail deer	Man days building traps	Work days horse packing
NOV.	0									26	--
DEC.	0									37	12
JAN.	4-7	57	1	57	0	1	8		4	--	5
FEB.	4-8	44	4	11	2	11	9		1	--	6
MAR.	5-8	41	0	--	1	1	3		4	--	--
		142	5	68	3	13	20	0	9	63	23
APR.	8	24	2	12.0	4	1	*NR	0	0	7	4
MAY	5-8	62	9	6.9	4	5	NR	9	0	--	4
JUN	5-8	53	10	5.3	11	12	NR	9	0	--	2
JUL	5-8	90	30	3.0	34	9	NR	4	2	--	7
AUG	5-8	51	7	7.3	6	4	NR	11	0	2	6
SEP.	5-8	27	0	--	0	0	NR	0	0		1
		307	58	5.3	59	31		33	2	9	24
GRAND TOTAL		449	63	7.1	62	44		33	11	72	47

*Not recorded

Table 4. Trapping records for 29 European wild boar, Spence Field study area, 1977.

Identification Number	Sex	Belled	No. times captured	Notes
0	F	X	2	
(0) piglet	M		1	
2	F	X	2	
3	F	X	4	
4	M		2	(UT Research) Killed off study area, 8/1/77
5	F		3	Later marked No. 16
6	M	X	2	Later became Radio Channel 1-A
8	M	X	7	
9	M		3	
18	M	X	1	
19	F	X	1	
B	F	X	3	
C	M	X	2	
D	M	X	1	
E	M	X	2	Shot by hunter off study area in park, 1/2/78
Radio Channel 4	F		2	
Radio Channel 4-A	F	X	1	
Radio Channel 8	M		1	
Radio Channel 12	F		3	

ble 4. Trapping records for 29 European wild boar, Spence Field study area, 1977. - Cont.

entification Number	Sex	Belled	No. times captured	Notes
C-12) piglet	M		2	
piglet	F		1	
piglet	F		1	
piglet	M		1	Died while taking blood sample
α	F		1	Injured, fate unknown
B	F		1	Not marked
nnumbered	M	X	1	
UP-36) --	F		1	Died during capture
UP-37) --	F		1	Died during capture
UP-89) --			1	Killed by bear while in trap

Table 5. Summary of breeding status in sows collected in 1976-77, Great Smoky Mountains National Park.

Month	Total Collected	No. Pregnant(%)		No. Lactating(%)		No. Barren	Live captures (? Barren or pregnant)
NOV.							
DEC.	1			2	(100)		
JAN.	2			2	(100)		
FEB.	1			1	(100)	1	
MAR.	5	1	(20)			2	1
APR.	3	2	(66)	1	(33)		
MAY	14	3	(21)	6	(43)	5	
JUNE	17	4	(23)	4	(24)	7	2
JULY	14	2	(14)	5	(36)	7	
AUG.	8			3	(36)	3	2
SEP.							
OCT.							

Table 6. Production of young by all sows of known age (n = 66 sows).

Sows		No.	No.	No. sows	
Number	Age (yrs.)	fetuses	piglets	breeding	(%)
35	0 - 1/2			0	(0)
4	1/2 - 1			0	(0)
6	1 - 1-1/2	5	4	2	(33)
8	1-1/2 - 2	5	1,3,3	4	(50)
3	2-1/2 - 3	5,6	3	3	(100)
2	4	5	3	2	(100)
5	5	4	5	1	(20)
2	6			0	(0)
1	7		2,3,4	3	(75)
66				15	

$\frac{15}{31}$ = 48% of sows > 6 months old were breeding.

Table 7. Summary of information from 23 lactating sows or their litter members, 1977

SOWS				PIGLETS							
ID No.	Date taken	Age	Condition	ID No.	No. piglets	M	F	Unident. Sex	Age	Notes	Backdated birth date
Radio 1	3/ /77	26 ms.	3		2	1	1				
Radio 12	5/11/77	14 ms.	1		4	2	2		2 wks.		4/27-4/29
0	6/4/77	26 ms.	3		3	1		2			
∝	6/4/77	26 ms.	4		4			4	1-2 wks.		5/20-5/27
139	12/29/76	--	--		3	1	2				
--	1/18/76	--	--		4	2	1	1	1-2 wks.		1/1-1/11
40	5/1/77	7	1		5[1]			5			
18	5/22/77	5	4		5			5		4 fetuses	
43	5/24/77	21-26 ms.	3		1			1	4-6 ms.	1 yearling	11/24-1/24
--	6/2/77	--	--		4	3	1		4-6 ms.	1 piglet in poor condition	12/2-2/2
15	1/9/77	4	4		3[1]						
87	7/6/77	26 ms.	2		3[1]			3			
110	7/13/77		2		2	2			2-3 wks.		6/21-7/1
113	4/8/77	--	1		5	1		4			

Table 7. Summary of information from 23 lactating sows or their litter members, 1977 - Cont.

SOWS				PIGLETS							
ID No.	Date taken	Age	Condition	ID No.	No. piglets	M	F	Unident. Sex	Age	Notes	Backdated birthdate
52	6/2/77	21-26 ms.	3		3	1		2	2-4 ms.		2/1-4/1
107	8/29/77	18-22 ms.	3		3[1]			3			
--	7/10/77	--		83	3	1		2		1 boar, 1 yearling	
--	7/3/77			73	1	1			4-6 ms.		1/3-3/3
--	7/4/77			74	2	1		1	6-8 ms.		11/4-1/4
--	8/2/77			95	2	1		1	4-6 ms.	1 sow, 1 unident.	12/2-4/2
--	8/4/77			103	3	3			4-6 ms.		12/2-4/2
--	5/ /77				2						4/15-4/18
--	5/ /77				3						4/21-4/21
					70	21	9	34			

---

[1] Litter sizes in these cases estimated by the number of active teats.

Table 8. Summary of information from 12 pregnant sows, 1977

	SOW				FETUSES			
ID No.	Date taken	Age	Condition	Group	No. fetuses	Length (centimeters)	Age (days)	Estimated birth date
36	5/10	26 ms.	4		5	14	68	6/25
57	6/14	3	4	1 yearling	3	26	110	6/19
55	6/1	4	4	1 yearling	5	26	110	6/5
56	6/1	26 ms.	4		6	25	110	6/5
75	7/4	18–22 ms.	3	3 adults	5	27	110	7/9
18	5/22	5	4	5 piglets	4	24	110	5/25
112	6/10	--	3		7	15	68–69	7/25
111	7/20	--	3	3 unident.	3	26	110	7/25
32	3/14	16–18 ms.	4		5	19	80–85	4/14
27	4/6	--	4		6	--		4/
30	4/11	--	--	(had lactated)	4	--		5/
35	5/24	--	3		4	27	110	5/29

Table 9. Monthly breakdown of reproductive status of 65 sows > 6 months old.

Month	No. Pregnant	No. Lactating	No. Barren	Unknown[1/] Barren or Pregnant	TOTAL
NOV.					
DEC.		1			1
JAN.		2			2
FEB.		1	1	1	
MAR.	1		2		
APR.	2	1			3
MAY	3	6	5		14
JUNE	4	4	7	2	17
JULY	2	5	7		14
AUG.		3	3	2	8
SEP.					
OCT.					
					65

[1/] Undetermined for live captures

Table 10. Summary of barren sows > 6 months old, 1977. Includes live captured sows which were either barren or pregnant, and reproductive status could not be determined.

ID No.	Date taken (1977)	Age of sow	Condition	Group
37	5/11	6 yrs.	2	-- t.a.
92	7/21	16-18 ms.	3	With 4 large piglets
2	6/4	> 26 ms.	3	1 Large nipple;lost litter?
82	7/6	9 ms.	3	
126	8/4	10-12 ms.	3	
131	8/19	~ 15 ms.	3	
21	2/18	12-14 ms.	3	Trapped with 12-14 ms. old males
34	3/4	26 ms.	--	Solitary
61	6/8	4-5 yrs.	3	Solitary
43	6/13	5 yrs.	3	Solitary
63	6/14	16-18 ms.	3	-- t.a.*
71	6/24	18-20 ms.	3	-- t.a.
72	6/24	18-22 ms.	3	-- t.a.
50	6/27	18-22 ms.	3	-- t.a.
84	7/6	6-8 ms.	3	84 & 85 caught together
85	7/6	6-8 ms.	3	84 & 85 caught together
94	7/11	18-20 ms.	3	Solitary
97	7/27	--		-- t.a.
101	7/29	16-18 ms.	--	-- t.a.

Table 10. Summary of barren sows < 6 months old, 1977 - Cont.

ID No.	Date taken (1977)	Age of sow	Condition	Group
31	3/5	16-22 ms.	4	Solitary
59	5/18	--	4	Solitary
32	5/18	--	--	Solitary
119	5/19	--	--	Solitary
50	5/31	5 yrs.	3	Solitary
102	8/1	6-8 ms.	3	Solitary
5	5/10	> 26 ms.	3	
3	6/18	∿ 12 ms.	3	
B	6/18	∿ 12-20 ms.	3	Susp. pregnant
19	8/3	> 26 ms.	3	Susp. pregnant
Beta	8/1	> 26 ms.	4	Susp. pregnant

---

*t.a. = trapped alone; group unknown

able 11. Field observations of wild boar along trails, 1977, off intensive study area

	Number in Group						
Group type	1	2	3	4	5	9	TOTAL
Yearlings	8	5					13
Sows	8						8
Males	5						5
Adult pairs		2					2
Unknown large pigs	16	3	4	1			24
Family		2	1	2	1		6
Extended family			1	2	1		4
Multiple family							0
Mixed group						1	1
							63

Table 11A. Field observations of wild boar on intensive study area, high human disturbance

	Number in Group						
Group type	1	2	3	4	5	9	TOTAL
Yearlings	1						1
Sows	3						3
Males							
Adult pair							
Unknown large pigs	21	3					24
Family				1			1
Extended family							
Multiple family							
Mixed							
							29

ble 12. Frequency of litter sizes from field observations of litters, Spence Field study area, 1977.

Age	5	4	3	2	1
-8 months	1	1	2	3	
-14 months		1		1	3

able 13. Field observations of the different age classes of wild boar.

N	0-4 ms.	4-8 ms.	8-14 ms.	14 ms.			8 ms. Unknown Yearling/Adult
				M	F	?	
ield Census: Little disturbed)							
07	14	7	22	5	20	3	36
High disturbed)							
5	3		1		4		27
Trap data)							
3	8	2	2	9	12		

Table 14. Sex and age - harvested animals

Area	0-4 months		4-8 months		8-14 months		14-26 months		26+ months	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Trap Spence	4	4	1	1	1	1	3	2	6	10
Harvest - Cades Cove			1			2	5	1	6	
Gregory-Harvest	6	2	4	5			1	9	4	11
Valleys - Tenn.	2	3			3		1	3	12	1
Valleys - N. Carolina	3	3	3	1			1	1	8	3

Table 15. Groupings of animals either shot or trapped, 1976-77.

MALES	Simple family group (in litter)	With sibling	Solitary (shot)	? Trap alone	Other group	W/adult (a pair)	TOTAL
Months: 0-8	35						35
8-10							
10-12				2			2
12-14		1		3			4
16-18				4			4
18-20		1		1			1
22-26			1	1			2
∿ 26			2	4			6
Years: 3			1	2		1	4
4			3	1			4
5			1	2			3
6			2				2
							67
FEMALES							
Months: 0-8	35						35
8-12		2	2				4
12-18	1	2	3				7
18-26	3			4	1		8
Years: 26-3 yrs.	1		2				3
4	2						2
5	2		3				5
6			1	1			2
7			1				1
?26+	3		2	1	1	1	8
							75

Table 16. Catchability test for variations from expected (trap proneness or shyness) from the mark/capture data (Orians and Leslie 1958, in Caughley 1977). Captures made between April 29 and July 31.

Number of recaptures (i)	Number of animals (f)
0	9
1	7
2	4
3	0
4	0
5	0
6	1

$\Sigma f = 21$

$\Sigma f \cdot i = 21$

$\Sigma f \cdot i^2 = 59$

Trap session	Number of recaptures (n)
1	0
2	0
3	2
4	0
5	2
6	7
7	8
8	2

$\Sigma \; n = 21$

$\Sigma \; n^2 = 125$

$$= \frac{\Sigma fi^2 - \dfrac{(\Sigma fi)^2}{\Sigma f}}{\dfrac{\Sigma fi}{\Sigma f} - \dfrac{\Sigma n^2}{(\Sigma f)^2}} = \frac{59 - \dfrac{(21)^2}{21}}{\dfrac{21}{21} \quad \dfrac{125}{(21)^2}} = 53.0$$

$\chi^2 = 53.0 > \chi^2_{.005\ (df = 20)} = 40.0$

$df = (\Sigma f)-1 = 20$

$p < .005$

NOTE: This test compares the variance of the trap data compared to that of the equivalent binomial expectation.

Table 17. Schnabel estimate[1] [2] of belled/unbelled animals at feeders, for the trapable population, Spence Field to Little Bald, 1977

Date	Feeding station	No. observed (Ni)	No. observed, belled (Xi)	No. belled in population (Mi)[3]	Population Estimate($\hat{N}$)
6/15	1	9	2	3	13.5
6/16	1	4	2	3	9.8
7/1	1	5	3	6	9.9
7/1	2	2	1	6	10.1
7/2	1	5	3	7	10.5
7/2	2	4	1	7	12.0
7/3	1	2	1	7	12.2
7/17	1	3	1	8	13.0
7/18	1	4	1	9	14.5
7/21	1	6	1	9	17.0
7/31	1	2	0	9	18.1
8/2	1	1	1	10	17.6
8/3	1	2	1	10	17.8*

---

[1] Schnabel estimate, $\hat{N} = \frac{\Sigma \text{ Ni Mi}}{\Sigma \text{ Xi}}$

[2] Includes only sessions when boar were observed.

[3] Mi = marked animals in areas of feeders; i.e., traps 1 - 6.

* Best estimate

Table 18. Schnabel estimate[1] of belled/unbelled animals observed along night census, Little Bald to Spence Field[2], 1977.

Date	No. observed (Ni)	No. observed, belled (Xi)	No. belled in population (Mi)[3]	Population Estimate ($\hat{N}$)
6/4	2	0	2	--
6/14	1	1	4	8.0
7/1	7	2	6	16.7
7/2	9	3	7	20.0
7/19	5	2	8	20.3
7/21	3	0	9	23.3
7/21	17	3	9	30.3
8/1	9	3	9	29.6*

---

[1] Schnabel estimate, $\hat{N} = \frac{Ni\ Mi}{Xi}$

[2] Includes the Appalachian Trail between Spence Field and Little Bald and upper 2 Km of Bote Mt. Road, and Eagle Creek Trail.

[3] Mi = belled animals taken in that area, traps 1 - 6.

* Best estimate

Table 19. Calculation of the Overton modification of the Schnabel method (Overton 1969) for population estimation of the Spence Field study area, 1977

Date	N	M	X	Mortality	NN	Overton Population Estimate	S^2
4/29	2	0	0	0	0.0	0.0	0.0
5/10	3	2	0	0	0.0	0.0	0.0
5/11	1	5	0	1	0.0	0.0	0.0
5/12	1	5	0	1	0.0	0.0	0.0
5/16	1	5	0	0	0.0	0.0	0.0
5/23	1	6	0	0	0.0	0.0	0.0
5/24	1	7	1	0	34.00	35.01	35.16
5/26	1	7	1	0	20.50	21.03	43.52
6/4	4	7	0	1	34.50	36.00	72.07
6/5	1	10	0	0	39.50	41.01	82.50
6/16	1	11	1	0	30.00	31.84	95.45
6/18	3	11	0	0	41.00	43.01	129.32
6/19	1	14	1	0	34.25	36.02	145.62
7/2	4	14	2	0	32.17	34.02	206.93
7/3	4	16	2	0	32.13	34.02	276.42
7/4	3	18	3	0	28.27	30.72	338.03
7/16	5	18	4	1	26.73	29.02	438.53
7/17	2	18	1	0	27.31	30.01	479.88
7/18	2	19	1	0	27.94	30.65	520.41
7/19	2	20	1	0	27.50	30.02	543.63

Table 19. Calculation of the Overton modification of the Schnabel method (Overton 1969) for population estimation of the Spence Field study area, 1977 - Cont.

Date	N	M	X	Mortality	NN	Overton Population Estimate	S^2
7/20	1	20	0	0	28.61	31.02	564.39
7/21	2	20	1	0	29.21	32.01	611.17
7/30	1	21	1	0	28.80	32.00	634.30
7/31	1	21	1	0	28.43	31.02	659.17
8/1	1	21	1	0	28.09	31.01	684.07
8/2	1	21	0	0	29.05	32.01	706.25
8/3	2	22	0	0	31.05	34.02	752.52
8/4	1	24	1	0	30.74	34.01	780.54
8/14	2	24	2	0	30.20	33.15*	836.60

* Best estimate

able 20. Input data and population estimates calculated by the Schumacher-Eschmeyer method (Schumacher-Eschmeyer 1943); 1977 trap data for ridgetop.

Date	Ni	Mi	Xi	Ni-Xi	Population Estimates $(\hat{N})$	Standard Deviation	Standard Error
4/2	2	0	0	2	0	0.	0
5/1	6	2	0	4	0	0.	0
5/2	3	6	2	1	11.00	.242424	5.19
6/0	5	7	0	4	31.42	.4756851	35.06
6/1	5	11	2	3	28.88	.318714	15.03
7/0	11	14	7	5	26.59	.242209	6.21
7/1	13	19	8	5	33.75	.2604187	6.57
7/3	2	24	4	0	32.08	.2412821	5.33
8/0	5	24	2	3	36.17	.2723455	6.27
8/1	2	27	2	0	34.87*	.2526070	5.30

*Best estimate

Table 21. Calculation of population estimate for the Spence Field study area, 1977, by the Eberhardt method (Eberhardt 1968; Caughley 1977) by vegetation type, all unbelled animals.

Data for K and W were fitted using the regression,

$$\text{Log } (1-P_x) = K\ (\text{Log } X) - K\ (\text{Log } W)$$

and then subjected to the Eberhardt calculation,

$$\hat{N} = \frac{n \quad 1000}{2 \cdot X \cdot L} \left[\frac{(K+1)^2}{2K\ (K+2)} \right]$$

(A) NORTHERN HARDWOODS

Distance from Trail (meters)	Number observed	$P_x = \frac{Nx}{N_o = 10}$	Log X = Midpoint of interval	Log $(1-P_x)$	Regression Coefficients
0-10[1/]	30.0	1.000	--	--	
10-20	22.0	.733	1.1761	-.573	K = .945
20-29	16.5	.550	1.3979	-.347	-K Log W = -1.65
30-39	7.5	.250	1.5441	-.125	W = 56.22_m
40-49	3.0	.100	1.6532	-.045	$\frac{(K+1)^2}{2K\ (K+2)}$ = .679
50-59	0.0	.000	1.7404	-.000	
60-70	1.0	.033	1.8129	-.015	r^2 = .948
TOTAL	80.0				

[1/] Observations recorded at multiples of 10 were divided between adjacent intervals.
N = 80 observations, L = 22.43 Km, $\overline{X}$ = 17.16 m

$$\hat{D} = \frac{(80)\ (1000)\ (.679)}{2\ (22.43)\ (17.16)} = \underline{70.6}/\text{Km}^2 \quad \text{N. hardwoods}$$

Table 21. Calculation of population estimate for the Spence Field study area, 1977, by the Eberhardt method, (Eberhardt 1968; Caughley 1977) by vegetation type, all unbelled animals - Cont.

(B) OAK-MAPLE-HARDWOODS

Distance from trail (meters)	Number observed	P_x	Log X	Log $(1-P_x)$	Regression Coefficients
0-10	20.15	1.00	--	--	$K = 1.09$
10-20	14.5	.71	1.1761	-.5336	$-K \log W = 1.76$
20-30	5.5	.27	1.3979	-.1357	$W = 41.16$ m
30-40	3.0	.15	1.5441	-.0687	$\frac{(K+1)}{2K\ (K+2)} = .648$
40-50	.5	.02	1.6532	-.0107	$r = .904$
	44.0				

L = 12.44 Km

$$\hat{D} = \frac{(44)\ (1000)\ (.648)}{2\ (12.44)\ (13.18)} = \underline{87.0/\text{Km}^2}$$ Oak-Maple-Hardwoods

Kelker's Method (Kelker 1945)

(C) GRASSY BALD

Distance from trail (meters)	Number observed	
0-10	6.0	$\hat{D} = \frac{n'\quad 1000}{2\quad D'\quad L} = \frac{12\ 1000}{2\quad 20\quad 16.77} = \underline{17.9/\text{Km}^2}$
10-20	6.0	
20-30	2.5	$D' = 20$m
30-40	1.0	$N' = 12$
40-50	.5	$L = 16.77$ Km
	16.0	

Table 21. Calculation of population estimate for the Spence Field study area, 1977, by the Eberhardt method (Eberhardt 1968; Caughley 1977) by vegetation type, all unbelled animals - Cont.

D. ALL OTHER TYPES

N	L	Population Estimate
0	5.15	0.0

Kelker's method uses only those observations (n') within D', a threshold distance beyond which some animals are assumed to be missed.

ALL VEGETATION TYPES COMBINED.

Kelker's method for density calculation for belled animals only, eastern half of Spence Field study area. All forest types were used since it was suspected that vegetation type did not affect the probability of observing wild boar.

Distance from trail (meters)	Number observed
0-5	0.0
5-15	3.0
15-25	2.5
25-35	4.0
35-45	2.5
45-55	1.0
55-65	1.0
	$\Sigma = 14$

L = 15.8 Km, n = 14 animals,

$n' = 12, \quad D' = 40m$

$$\hat{D} = \frac{n' \quad 1000}{2 \cdot D \cdot L} = \frac{12 \cdot 1000}{2 \cdot 40 \cdot 15.8} =$$

$$= 9.49/Km^2$$

(using belled animals)

Table 22. Kelker (1944) estimation of wild boar density, entire extensive census area, 1977.

1. Gray Beech/Northern hardwoods

$$\hat{D} = \frac{N' \cdot 1000}{2 \cdot D' \cdot L} \qquad D' = 30m,\ n' = 68.5,\ L = 22.43$$

$$\hat{D} = \frac{(68.5) \cdot 1000}{2 \cdot 30 \cdot 22.4} = 50.9 \text{ animals per Km}^2$$

2. Oak-maple/red maple-sourwood-heath

$$\hat{D} = \frac{(20.5 \cdot 1000}{2 \cdot 10 \cdot 12.44} = 82.4 \text{ animals per Km}^2$$

3. Grassy Bald

$$\hat{D} = \frac{12 \cdot 1000}{2 \cdot 20 \cdot 16.77} = 17.89 \text{ animals per Km}^2$$

Table 23. Density estimate by vegetation type for entire study area.

Vegetation type	(/Km^2) $\hat{D}$	(/Km^2) [1/] $\hat{D}'$	(Km) Distance traveled	Number seen	(Km^2) Area	Absolute number (D' • A)
Gray Beech/ N. hardwood	70.56	12.9	22.43	80	.55	7.1
Oak-maple/ sourwood-...	86.95	15.9	12.44	44	5.33	84.7
Grassy Bald	17.89	3.3	16.77	16	.17	.6
Other types	0.0	0.0	5.07	0	5.55	0.0

[1/] Estimated daytime densities

Table 24. Eberhardt (1968) estimation of wild boar density, Russell Field to Spence Field only, using strip census data, 1977.

1. Gray Beech/Northern hardwoods

$$D = \frac{(23)\ (1000)\ (.574)}{2 \cdot (16.60)\ (5.52)} = 72.04 \text{ animals per Km}^2$$

2. Oak-maple/Red maple-sourwood-heath

$$D = \frac{(44)\ (1000)\ (.648)}{2 \cdot (13.18)\ (12.44)} = 86.95 \text{ animals per Km}^2$$

3. Grassy Bald

N = 7, sample size too small for this method

Table 25. Kelker (1944) estimation of wild boar density, Russell to Spence Fields, 1977.

1. Gray Beech/Northern hardwoods

$$\hat{D} = \frac{n' \cdot 1000}{2 \cdot D'm \cdot Lkm} \qquad D' = 20m,\ N' = 15,\ Lm = 5.52$$

$$\hat{D} = \frac{15\ \ 1000}{2 \cdot 20 \cdot 5.52} = 67.93 \text{ animals per Km}^2$$

2. Oak-maple/Red maple-sourwood-heath

D' = 10m, N' = 20.5 animals, Lm = 12.44 Km

$$\hat{D} = \frac{20.5 \cdot 1000}{2 \cdot 10 \cdot 12.44} = 82.40 \text{ animals per Km}^2$$

3. Grassy Bald

D = 20m, n' = 7 animals, L = 14.64 Km

$$\hat{D} = \frac{7 \cdot 1000}{2 \cdot 20 \cdot 14.64} = 11.95 \text{ animals per Km}^2$$

Table 26. Assumptions of mark-recapture.

Four assumptions need to be met in order to obtain accurate results with the mark/recapture methods we used (Caughley 1977):

1. The probability of capturing an animal is the same for all individuals in the population.
   A test was made to compare the variance of trap data to that of the equivalent biomial expection. Catchability was not equal for all animals ($\chi^2 = 53.0 > \chi^2_{.005\ (df=20)} = 40.0$). Animals were both trap prone and trap shy:

   a. Three animals captured in the trapline and radio-tracked all summer in the immediate vicinity of the trapline were never recaptured; i.e., they became trap shy.

   b. One animal was trap prone and was captured seven times.

   c. We observed many unmarked animals all season long near the trapline, suggesting they were either trap shy or their particular movements did not bring them near the traps. Unequal catchability would bias downwards population estimates.

2. No animal is born or immigrates into the area between marking and recapture.
   We had no evidence of immigration after April 27, and we observed only two litters born after that date.

3. Marked and unmarked individuals die or leave the area at the same rate.
   Mortality was believed equivalent for the marked animals once released from the traps. We observed no evidence of emigration prior to August 1.

4. No marks are lost.
   Each animal was marked with a collar and two ear tags. No animals were observed to lose all three.

Table 27. Assumptions of strip census.

Our ability to meet the basic assumption of strip census techniques (Seber 1973) is listed here:

1. Animals are randomly and independently distributed over the study area.
   This appeared to be true for a narrow band along the ridgeline through which we censused.

2. The sighting of one animal is independent of the sighting of another.
   Groups are observed. However, this will not alter the density estimate, but will increase its variance (Seber 1973).

3. No animal is counted more than once.
   This was probably true, since animals which flushed generally moved downslope, away from the transect line, rather than forward along it.

4. When animals are observed after being flushed, they are recorded in the exact position where startled.
   This appears to be true, although some animals could have quietly moved away away from the observer without being detected.

5. The response behavior of the population does not substantially change in the course of running a transect.
   Apparently true.

6. Individuals are homogenous with regard to their response behavior, regardless of sex or age.
   No data.

7. The probability of an animal being seen, given that it is right angle distance, Y, from the line of travel (irrespective of which side of the path it is on) is a simple function, $g(Y)$ say, of Y such that $g(o) = 1$ (i.e., probability is 1 of seeing an animal on the path).
   Apparently true.

Table 28. Density corrections for ridgeline.

We recognized that our strip census intersected a nighttime concentration of animals feeding along the ridgeline, and we attempted to calculate the average width of this aggregation. The number of different belled animals known to occupy the eastern half of the study area averaged 6.6 (due to continued marking of animals through the period). The density of belled animals only in this eastern half was calculated as 9.49 belled wild boar per square kilometer, using Kelker's method:

Distance from observer (meters)	Number observed
0 - 5	0.0
5 - 15	3.0
15 - 25	2.5
25 - 35	4.0
35 - 45	2.5
45 - 55	1.0
55 - 65	1.0

$L = 15.8$ kilometers

$n = 14$ animals

$n' = 12$

$D' = 40$ meters

$$\hat{D} = \frac{n' \cdot 1000}{2 \cdot D \cdot L} = \frac{12 \cdot 1000}{2 \cdot 40 \cdot 15.8} = 9.49 \text{ per square kilometer}$$

This density (9.49 per square kilometer) of belled animals should then equal the known number of belled animals (6.64) divided by the area where they are located (A = 2.3 kilometers long • kilometers wide),

$$D = \frac{\bar{n}}{L \cdot W}$$

$$9.49 = \frac{6.64}{2.3 \cdot W}$$

$$W = .304 \text{ kilometer}$$

The estimated average width of the feeding aggregation is 3.04 kilometers or 150 meters on each side of the ridgeline. We then estimated population size, using the calculated density for all unbelled animals ($\hat{D}_{unbelled}$), the density of unbelled animals ($\hat{D}_{belled}$), and the known number of belled animals (N_{belled}) using the formula:

Table 28. Density corrections for ridgeline. - Cont.

$$\frac{\hat{D}_{\text{unbelled}} + \hat{D}_{\text{belled}}}{\hat{D}_{\text{belled}}} = \frac{\hat{N}\ \text{study area (eastern half)}}{N_{\text{belled}}}$$

where $\hat{D}_{\text{unbelled}}$ is the mean of wild boar in each vegetation type weighted by the availability of the types (kilometers of each type along census route),

$$\hat{D}_{\text{unbelled}} = \frac{(70.6/\text{km}^2 \cdot 1.04\ \text{km}) + (87.0/\text{km}^2 \cdot 2.13) + (17.9/\text{km}^2 \cdot 1.15) + (0.0 \cdot 0.63)}{4.95/\text{km}}$$

$$\hat{D}_{\text{unbelled}} = 56.4\ \text{wild boar/km}^2$$

therefore,

$$\frac{(56.4 + 9.49)}{9.49} = \frac{\hat{N}\ \text{study area (eastern half)}}{6.64},$$

$$\hat{N}_{1/2\ \text{study area}} = 46.1\ \text{wild boar on ridgeline}$$

We then used the same process to determine the population for the entire study area,

$$N_{\text{belled entire study area}} = 8.00$$

$$L_{\text{entire study area}} = 4.9\ \text{km}$$

$$\hat{D}_{\text{entire study area}} = \frac{8.0}{(.304)\ (4.9)} = 5.37/\text{km}^2$$

$$\hat{N}_{\text{entire study area}}\ \frac{(56.4 + 5.37)(8.00)}{5.37} = 92.0\ \text{wild boar on ridgeline}$$

The estimate of 92.0 wild boar is calculated only for the ridgeline feeding concentration; however, two sources of data support a significant nighttime concentration:

1. Our extensive audio-observations of belled animals, 4:30 p.m. - 12:00 midnight were concentrated along the ridgeline.

2. Rooting transects were highest for ridgeline vegetation types (refer back to Table 13 in text).

Table 29. Preliminary survival rates for wild boar, 1976-77.

Age (years) X	Actual Number	Survival l_x	Smoothed Survival l_x
0 - 1/2	47		1.00
1/2 - 1	23	.48	.49
1 - 1-1/2	14	.60	.30
1-1/2 - 2	10	.71	.21
2 - 2-1/2	9	.90	.127
2 -1/2 - 3	5	.55	
3 - 3-1/2	4	.80	.059
3-1/2 - 4	3	.75	
4 - 4-1/2	3	1.00	.043
4-1/2 - 5	2	.66	
5+	13		.002
	131		

Table 30. Preliminary demographic parameters for European wild boar in Great Smoky Mountains National Park. Fl = mast failure, Fr = fair mast crop, and Ab = abundant mast crop (see Tipton, in press)

Age	Litter Size	PERCENT BREEDING					
		Winter			Spring		
		Fl	Fr	Ab	Fl	Fr	Ab
0 - 1/2	0.0	.000	.000	.000	.000	.000	.000
1/2 - 1	0.0	.000	.000	.000	.000	.000	.000
1 - 1-1/2	2.4	.036	.090	.140	.090	.140	.200
1-1/2 - 2	2.4	.060	.130	.200	.130	.200	.330
2 - 2-1/2	2.4	.100	.250	.330	.250	.330	.550
2-1/2 - 3	2.4	.100	.250	.330	.250	.330	.550
3 - 3-1/2	2.4	.100	.250	.330	.250	.330	.550
3-1/2 - 4	2.4	.100	.250	.330	.250	.330	.550
4 - 4-1/2	2.4	.100	.250	.330	.250	.330	.550
4-1/2 - 5	2.4	.100	.250	.330	.250	.330	.550
5+	2.4	.100	.250	.330	.25-	.330	.550

Table 31. Groupings of marked wild boar.

	Age	No. individuals	Total no. observations	GROUP TYPE			
				Solitary	Mixed sexes	Male group	Family group
MALES	8 - 14 months	4	18	15	2	1	
	14 - 26+ months	5	17	15	2	1	
FEMALES	8 - 14 months	1	8	2	5		1
	14 - 26+ months	6	28	9	1		16

Table 31. Field Observations, 1977

BLACK BEAR ATTACKS

July 20 - A black bear killed a 30 pound (14 kilograms) piglet caught in a trap near Little Bald. The bear killed the piglet with a neck bite and consumed some meat in the shoulder area. The bear had broken a hole in the trap and attempted to drag the piglet out of the trap.

July 31 - At 2:00 p.m. we heard a pig squealing and ran towards Trap No. 1. An adult black bear was attempting to kill a yearling male hog (No. 8) which weighed 110 pounds (50 kilograms) and had been captured in the trap. The bear was straddled on the hog's back and, grasping base of the neck, was shaking the hog. The hog still maintained its feet, but would probably have soon succumbed (estimated attack time - seven minutes). At F. Singer's approach the bear released its hold and then moved off.

DOOR LIFTING

Radioed Sow No. 12 grabbed the door neeting in her mouth on her second capture. At the approach of B. Ackerman, on her third capture, she grabbed netting in her mouth and this time threw the door up and crawled under to escape.

Sow No. B was observed to escape from a guillotine-style trap door on August 3. She hooked a tusk under a protuberence on the door, threw it up three times, and escaped under it on the third attempt.

TABULATIONS AND STATISTICAL ANALYSES

EUROPEAN WILD BOAR DATA

JOB 1. Summary of hunting statistics, ridgeline study, summer of 1977, 15 nights

	No. pigs shot	No. pigs observed	Kilometers hiked	Hours worked
	1	3	7.0	6.0
	1	9	2.5	4.0
	3	17	1.0	3.5
	1	2	2.5	6.5
	0	7	2.7	2.5
	0	0	3.5	2.5
	3	7	1.5	6.0
	1	3	3.6	7.0
	0	11	9.5	4.5
	0	2	2.0	2.5
	0	2	2.9	2.5
	1	5	3.6	6.0
	1	13	3.0	5.0
	2	4	3.0	4.5
	0	2	2.6	4.5
$\Sigma\gamma$	14	87	50.9	68.5
Nightly range	0-3	0-17	1.0-9.5	2.5-7.0
$\overline{\gamma}$	.93	5.8	3.4	4.6
$\Sigma\gamma^2$	28	833		
$\frac{\Sigma\gamma^2 - \frac{(\Sigma\gamma)^2}{N}}{N-1}$	$\frac{28 - \frac{196}{15}}{14}$	$\frac{833 - \frac{7569}{15}}{14}$		
S^2	1.07	23.4		
S	1.034	4.84		
$SD = \frac{S}{\sqrt{\ }}$	.267	1.25		

JOB 2. Did the location of traps (within a season) affect their success?

Apparently it did not. It was difficult to evaluate all the trap features; apparently all were located in a high density stratum.

JOB 3. Did the design of trap doors affect their success?

Yes. ($P < .005$)

TOTAL		1*	2*	3*	4^{o}	5^{o}	6^{o}	7^{*}	8^{o}
58	No. captures	21	6	5	1	7	5	13	0
56	No. escapes	6	8	10	8	9	5	5	5
114	TOTAL	27	14	15	9	16	10	18	5

* swing style

^{o} Guillotine style

OBSERVED

	Guillotine	Swing	
Captures	13	45	58
Escapes	27	29	56
TOTAL	40	74	174

EXPECTED VALUES

20.4	37.6
19.6	36.4

$$\chi^2 = \frac{(\text{Obs}-\text{Exp})^2}{\text{Exp}}$$

$$= \frac{(13-20.4)^2}{20.4} + \frac{(27-19.6)^2}{19.6} + \frac{(45-37.6)^2}{37.6} + \frac{(29-36.4)^2}{36.4}$$

$$= 2.68 + 2.79 + 1.45 + 1.50$$

$$\chi^2 = 8.42 > \chi^2_{.05} = 3.84$$

JOB 4. Was the proportion of piglets caught in traps less than the number expected (field census proportions) due to a trap bias against piglets?

I. Litter size significantly different?

Field N

5
4
3
3
2
2
2

Field $3.0 \pm .436$

Harvest $3.04 \pm .239$

$(P < .05)$

$$\Sigma Y = 21$$

$$\bar{Y} = 3.0$$

$$\text{Range} = 2\text{-}5$$

$$\Sigma Y^2 = 441$$

$$\frac{\Sigma Y^2 \quad \frac{(\Sigma Y)^2}{N}}{N-1} = \frac{71 - \frac{441}{7}}{6}$$

$$S^2 = 1.333$$

$$S = 1.154$$

$$\frac{S}{\sqrt{n}} = .436$$

II. Possible functioning of multiple-capture-type doors.

Capture	No. animals	Identification Nos.	
		Male	Female
1	2	No. 4	No. 5
2	2	No. 6	No. 3
3	2	No. 8	No. 3
4	2	No. 6	No. 3

JOB 5. Summary of feeding station observations, 1977

	No. wild boar observed	No. adults	No. piglets	No. belled animals	Man-hours
	9	6	3	2	1
	4	3	1	2	3
	5	5	0	3	5
	2	2	0	1	2
	5	5	0	3	2
	4	4	0	1	2.5
	2	2	0	1	2.5
	3	3	0	1	4
	4	4	0	1	3
	6	6	0	1	5
	2	2	0	0	2
	0	0	0	0	2.75
	0	0	0	0	2.75
	1	1	0	1	1.5
	2	2	0	1	3.5
	0	0	0	0	.2
	0	0	0	0	2.
	0	0	0	0	4.
$\Sigma\gamma$	49	45	4	18	48.45
$\overline{\gamma}$	2.72	2.50	.22	1.00	2.69
$\Sigma\gamma^2$	241	189	10	34	
$\frac{\Sigma\gamma^2 - \frac{(\Sigma\gamma)^2}{N}}{N-1}$	$\frac{241 - \frac{2401}{18}}{17}$	$\frac{189 - \frac{2025}{18}}{17}$	$\frac{10 - \frac{16}{18}}{17}$	$\frac{34 - \frac{324}{18}}{17}$	$\frac{2347.4 - \frac{176.6}{18}}{17}$
S	6.33	4.50	.54	.94	132.00
S	2.51	2.12	.73	.97	11.49
$SD = \frac{S}{\sqrt{n}}$	.59	.499	.172	.228	2.708

JOB 6. Average home range width for marked wild boar, linear with ridgeline.

Sex	Identification No.	No. sightings	Diameter-linear with ridge
MALES	8	13	.6
	9	3	1.6
	C	3	2.0
	E	11	1.4
FEMALES	0	4	1.3
	2	6	.8
	5	3	1.1
	B	4	.8
	Channel 12	7	.8

Female	Male	Female + Male
$n = 5$	$n = 4$	$n = 9$
$\Sigma\gamma = 4.8$	$\Sigma\gamma = 5.6$	$\Sigma\gamma = 10.4$
$\bar{\gamma} = .96$	$\bar{\gamma} = 1.4$	$\bar{\gamma} = 1.16$
$\Sigma\gamma^2 = 4.82$	$\Sigma\gamma^2 = 8.88$	$\Sigma\gamma^2 = 13.7$
$S^2 = .05$	$S^2 = .35$	$S^2 = .21$
$S = .23$	$S = .59$	$S = .46$
$\bar{\gamma} \pm .29$	$\pm .94$	$\pm .35$
$.67 \leq \gamma \leq 1.25$	$.46 \leq \gamma \leq 2.34$	$.81 \leq \gamma \leq 1.51$

JOB 7. What is the mean and SD of fetal and litter sizes?

	Fetal litters N	Field litter size	Harvest litter size N	 N
	5	5	2	2
	3	4	4	5
	5	3	3	3
	6	3	4	3
	5	2	3	3
	4	2	4	1
	7	2	5	2
	3	2	5	2
	3		5	2
	5		1	3
	6	Field + Harvest	4	2
	4	Combined	3	3
ΣY =	57	91		70
$\bar{Y}$ =	4.75	3.03		3.04
=	3-7	1-5		1-5
ΣY^2 =	3,249	8,281		4,900
$\frac{\Sigma Y^2 - \frac{\Sigma Y^2}{N}}{N-1}$ =	$\frac{287 - \frac{3,249}{12}}{11}$	$\frac{313 - \frac{8,281}{30}}{29}$		$\frac{242 - \frac{4,900}{23}}{22}$
S^2 =	1.545	1.275		1.318
S =	1.242	1.129		1.148
$\frac{S}{\sqrt{n}}$	.358	.206		.239

$n-1 = 29$

$t_{.05}$ .206 =

(2.405)(.206) = .495

JOB 8. Did a smaller proportion of young sows (1-2 years) breed than expected (expected values being older sons (2-7 years)?

No! ($P < .05$)

	No. breeding	No. non-breeding	
Sows 1-2 years	6	8	14
Sows 2-7 years	9	4	13
	15	12	

Expected values	
7.7	6.2
7.2	5.7

$$\chi^2 = \frac{(\text{Obs}-\text{Exp})^2}{\text{Exp}}$$

$$\chi^2 = \frac{(6 - 7.7)^2}{7.7} + \frac{(9 - 7.2)^2}{7.2} + \frac{(8 - 6.2)^2}{6.2} + \frac{(4-5.7)^2}{5.7}$$

$$\chi^2 = .375 + .45 + .522 + .507$$

$$\chi^2 = 1.85 < \chi^2_{.05} = 3.84$$

JOB 9. Did a larger proportion of sows breed in summer or winter?

No!

	Summer	Winter	
Breeding	21	5	26
Non-breeding	26	4	30
	47	9	56

Expected values	
21.8	4.2
25.2	4.8

$$\chi^2 = \frac{(\text{Obs}-\text{Exp})^2}{\text{Exp}}$$

$$\chi^2 = \frac{(21-21.8)^2}{21.8} + \frac{(26-25.2)^2}{25.2} + \frac{(5 - 4.2)^2}{4.2} + \frac{(4 - 4.8)^2}{4.8}$$

$$\chi^2 = .029 + .025 + .152 + 1.33$$

$$\chi^2 = .336 < \chi^2_{.05} = 3.84$$

JOB 10. Were number of piglets different in shot and trap samples? No!

	0 - 8 months	7 - 8 months	
Shot	9 (29%)	22	31
Trap	23 (40%)	35	58
	32	57	89
Expected	11	20	
	21	37	

$$\chi^2 = \frac{(Obs-Exp)^2}{Exp}$$

$$\chi^2 = .414 + .232 = .22 + .124 = .990 < 3.84$$

JOB 11. No piglets in trap and field data? No!

	0 - 4 months	All other ages	
Field obs.	14	93	107
Trap data	22	25	33
	22	118	140

Expected values

Field	16.8	90.2
Trap	5.2	27.8

$$.466 + 1.507 + .086 + .282 = 2.34$$

JOB 12. Were there more sows and suckling piglets in poor condition in the summer or the winter?

Apparently not; too few samples!

Season	No. litters 1 individual (sow or piglet) Poor	Good condition	
Nov. - Apr.	1	3	4
Apr. - Sep.	7	10	17
	8	13	21

Expected values

Nov. - Apr.	1.52	2.5
Apr. - Sep.	6.5	10.5

Too many samples below 5

JOB 13. Were the number of groups flushed in high disturbance area different from light disturbance area? Yes!

	No. flushed	No. that did not flush	
Light disturbance	6	57	63
High disturbance	16	13	29
	22	70	92

Expected

15	48
7	22

$$\chi^2 = \frac{(\text{Obs}-\text{Exp})^2}{\text{Exp}}$$

$$= \frac{(6-15)^2}{15} + \frac{(16-7)^2}{7} + \frac{(57-48)^2}{48} + \frac{(13-22)^2}{22}$$

$$= 5.40 + 11.571 + 1.687 + 3.681$$

$$\chi^2 = 22.34 > \chi_{.05} = 3.84$$

JOB 14. Field observations, Spence Field.
What is the average group size?

	Number in group					
	1	2	3	4	5	9
No. Groups	37	12	6	5	2	1

	Lightly disturbed areas	Highly Disturbed Areas
ΣY	$= 118$	35
	$= 1-9$	$1 - 4$
$\overline{Y}$	$= 1.87$	1.206
ΣY^2	$= 622$	78
$\frac{\Sigma Y^2 - \frac{(\Sigma Y)^2}{N}}{N-1}$	$= \frac{622 - \frac{13924}{63}}{62}$	$\frac{78 - \frac{1225}{29}}{28}$
s^2	$= 6.467$	1.277
s	$= 2.543$	1.130
$\frac{s}{\sqrt{n}}$	$.32$	$.209$
	$(.32)(2.00) = .64$	$(2.048)(.209) = .428$

(95% confidence intervals) 1.87 ± .64 (P .05) 1.206 ± .43 ($P < .05$)

VS. Disturbed eastern half of Spence study area?

No. groups	1	2	4
	25	3	1

Disturbed area $.776 \leq \chi \leq 1.6$

Lightly disturbed $1.23 \leq \chi \leq 2.51$

JOB 15. Male:female ratio, summer of 1977, ridgelines and valleys. Yes!

	Males	Sows	
Ridgeline	19	52	71
Valley	20	5	25
	39	57	96

Expected values

Ridgeline	28.8	42.2
Valley	10.15	14.8

$$\frac{(Obs-Exp)^2}{Exp}$$

$$= \frac{(19 - 28.8)^2}{28.8} + \frac{(20 - 10.15)^2}{10.15} + \frac{(52 - 42.2)^2}{42.2} + \frac{(5 - 14.8)^2}{14.8}$$

$$= 3.33 + 9.56 + 2.27 + 6.49$$

$$\chi^2 = 21.65 > \chi^2 = 3.84$$

JOB 18. Were more males found in poor condition in lower elevations than along the ridgeline during summer?

	No. males in poor condition	No. males in good condition	
Ridgelines	0	21	21
Valleys	3	15	18
	3	36	39

* Expected values

1.6	19.4
1.4	16.6

$$\frac{(1.6)^2}{16.5} + \frac{(1.6)^2}{1.6} = .155 + 1.6$$

$$3.84$$

* Values less than S; therefore use Yates Correction for small sample.

INTRODUCTION

In the late 1940's, European wild boar invaded Great Smoky Mountains National Park (GRSM) and have since occupied all but one-fourth of the preserve (Bratton 1975). The types of foods eaten by wild boar (Scott and Pelton 1975) and effects of their rooting in certain habitats (Bratton 1975; Howe and Bratton 1976) have been investigated. The purpose of this study was to sample high elevation areas not investigated in earlier study and to determine the specific species of forages being taken by wild boar.

STUDY AREA

Collection of specimens was concentrated in the northwest (37 stomachs) and southwest (5 stomachs) quarters of the park. and winter specimens were mostly from the Cades Cove area. High elevation spring and summer specimens were collected at the ridgeline between Derrick Knob and Sheep Pen Gap, within the western half of the park's high elevation ridgeline.

PART II. SEASONAL FOOD HABITS OF EUROPEAN WILD BOAR - 1977

Bruce B. Ackerman, Mark E. Harmon, and Francis J. Singer

METHODS

Stomach contents were analyzed from European wild boar shot by the park control team, the ranger staff, and the wildlife biologist.

Whole stomachs were either frozen or preserved in 10 percent Formalin solution. The total volume of the stomach contents was measured while still moist, using graduated beakers. Fall and winter samples were sieved through a series of screens of decreasing size (10 millimeters, 5.66 millimeters, and 3.36 millimeters), and the volume of each fraction was measured. An ocular estimate of relative volume was made for each food item, through several subsamples of each size-fraction. Spring and summer samples could not be sieved due to high foliage content. These stomach contents were carefully sorted through, and all animal matter and larger pieces of vegetation were removed. The remaining material was examined using the Point-Analysis method (Chamrad and Box 1964), in which a certain number of fragments (usually 100) from the stomach are chosen, using a fixed grid, and identified. The relative volume of each food item is determined from its frequency in respect to all food items. Animal matter was measured using a graduated cylinder to the nearest 0.1 milliliter, plant fragments to the nearest milliliter. Smaller volumes were recorded as trace (tr). Results of analysis for groups of stomachs were computed

using the Aggregate Volume method (Martin et al. 1946), in which relative volume is calculated as total volume of each food item divided by total volume of all food items. Frequency of occurrence is calculated as the percentage of all stomachs containing a given item.

Food items were identified to the lowest possible taxon through microscopic observation and the use of a dissecting microscope (10X to 25X). Plant items could often be identified to species level. Insects were usually identified to family and other invertebrates to order. Salamanders could often be identified to species level; other vertebrates usually could not. Finely masticated and partially digested plant materials could often be identified using characteristics of shape, color, venation, and texture. Finely ground starchy pulp was separated from protein-rich animal tissues by staining with iodine. Unidentified food items were preserved for future identification.

Plant nomenclature is from Fernald (1950). Animal nomenclature is from Borror and White (1970), Chu (1949), and Huheey and Stupka (1967). Identification of mammalian hair is from Day (1966).

Vegetation plots were set up at collection and feeding sites visited by Laboratory personnel to determine the vegetation type and to help quantify food availability. Either of two sampling schemes were used. In the first, tree species density and base area were calculated by measuring all trees within a 10 by 10

meter plot. Shrub and herb layers were quantified using ocular estimates of cover (percent of surface area obscured by the plants) in ten 1 by 1 meter subplots. On the second, 20 trees were sampled using the Point-centered Quarter method. Shrub and herb cover was measured on five 5 by 5 and five 2 by 2 meter subplots, respectively. Environmental parameters were also recorded at each site.

A 5 by 5 meter phenology plot was established in the Gray Beech forest (1,520 meters elevation) and checked weekly. Shrub and herb cover was monitored, as well as leaf cover of selected nearby trees. Date of flowering, fruit set, and fruit drop were also observed for various plant species in the area.

Vegetation types with rooting were sampled by Rooting Line Transects. Each was 100 paces (approximately 100 meters), and percent length rooted and depth of rooting were recorded. Rooting depth was separated into three categories: (1) litter disturbance, (2) A-soil-horizon disturbance, (3) B-soil-horizon disturbance. Transects were made roughly in proportion to vegetation type occurrence along trails. When snow cover permitted, feeding and rooting were examined by following tracks. Depth and extent of rooting, as well as site location in respect to elevational, topographical, and vegetational gradients, was recorded.

Feeding observations were attempted whenever animals were encountered. Feeding behavior such as number of mouthfuls of each food item and time spent searching for food was recorded.

RESULTS

Stomach contents from 42 free-ranging wild boar collected between October 29, 1976, and September 10, 1977, were analyzed. Twenty-two of these animals were obtained farther than five miles from any road. The specimens were grouped according to season and elevation (Table 1), but not by vegetation type since several specimens were found to contain foods not present in the vegetation type where they were collected.

Stomachs from nine trapped animals were examined, but because of very strong influence of bait upon diet, the data was only used to note the presence of unusual food items. One control team working in the backcountry during the spring season was only able to collect partial samples. The Aggregate Volume method of computation, unfortunately, limits the contribution of such small samples, although they were similar to others in content.

Table 1. Elevation, vegetation type, and seasonal distribution of wild boar stomachs collected.

Vegetation Type	Low Elevation - 520-910 meters				High Elevation - 910-1,680 meters			
	Fall 9/21/76- 12/20/76	Winter 12/21/76- 3/20/77	Spring 3/21/77- 6/20/77	Summer 6/21/77- 9/20/77	Spring 3/21/77- 6/20/77	Summer 6/21/77- 9/20/77		
Grassy Bald						4		
Gray Beech					5	6		
Northern Hardwood					5	2		
Cove Hardwood					1			
Mixed Oak	5	3		1				
Pine								
Pasture	4	2	1	2				
TOTAL	9*	5	2	3	11	12	=	42

*Four of these stomachs were not presented.

The number of samples within a season was too small to detect any difference in diet by ages or sexes. All results were therefore grouped by seasons and elevations.

The percent volume and percent frequency of various categories of ingesta for each of six season/elevation groups are presented in Tables 2 and 3. A graphic display of seasonal percent volume is shown in Figure 1.

Fruits

Acorns of several species were the major portion of the diet in fall, winter, and spring at low elevations. In summer, at high elevations, serviceberries and blueberries (*Vaccinium* spp.) were important during short periods. At low elevations in summer, the samples was dominated by one individual's consumption of Japanese quince (*Chanomeles lagenaria*), an introduced species found at old homesites.

Foliage

Green foliage (leaves and stems) composed the bulk of the high elevation spring and summer diet (73.2 and 52.3 percent). Vernal herbs such as spring beauty (*Claytonia virginica*), great chick weed (*Stellaria pubera*), *Trillium* spp. and *Viola* spp., and aestival herbs such as white snakeroot (*Eupatorium rugosum*), wood nettle (*Laportea canadensis*), and *Aster* spp. were most important. More than 23 species of herbs were eaten. Grasses, especially sedges (*Carex* spp.) were found in all seasons in all locations, although they were never a major component (0.6 to 8.3 percent) of the diet.

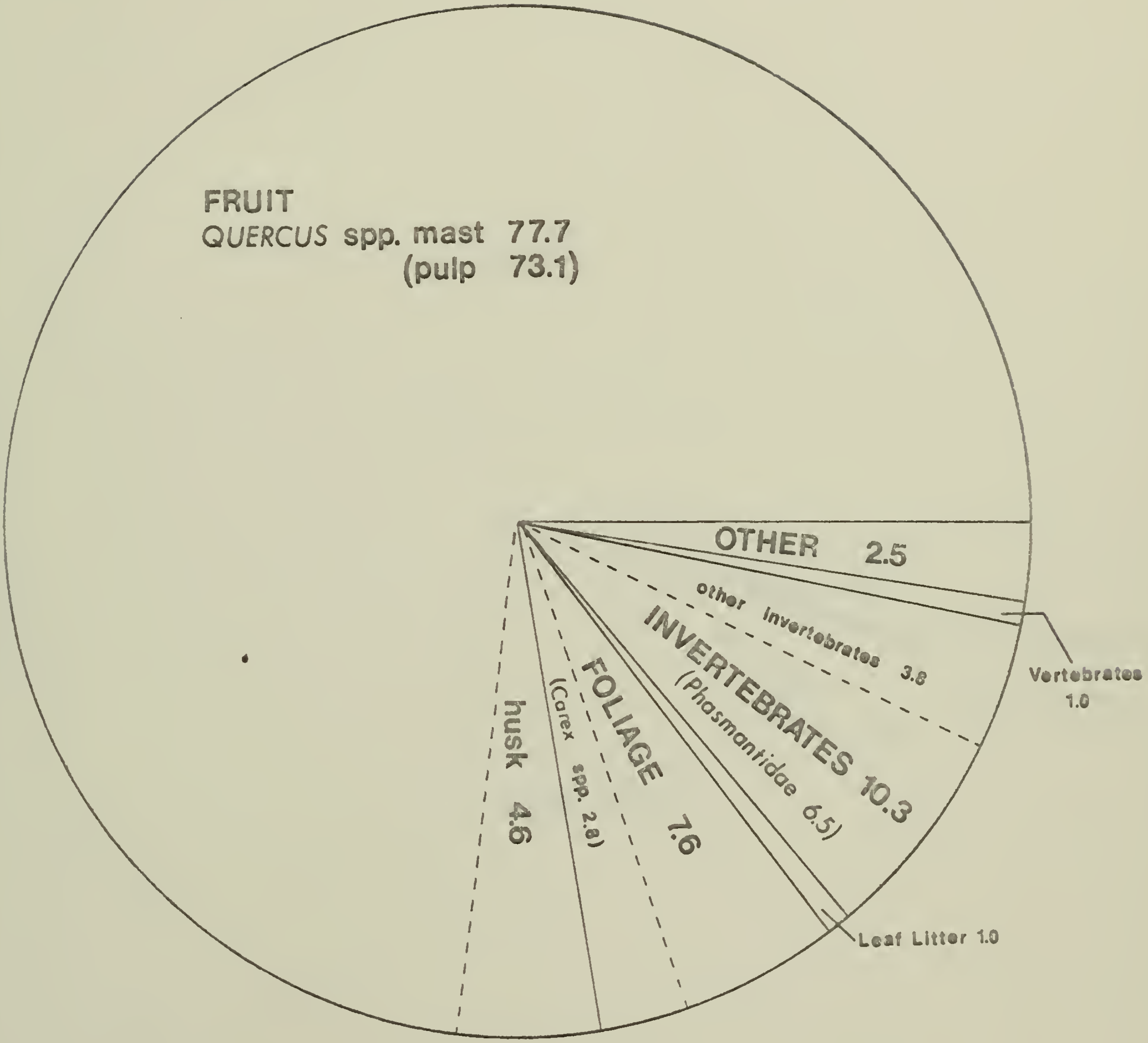
Roots and Bulbs

This category included woody roots, tubers, bulbs, corms, rhizomes, and other underground bodies. Roots and bulbs, predominantly spring beauty (*Claytonia virginica*) corms were an important part of spring and summer diet (25.2 and 31.1 percent). Only in summer, at low elevations, were woody roots found to be an important constituent (13.2 percent).

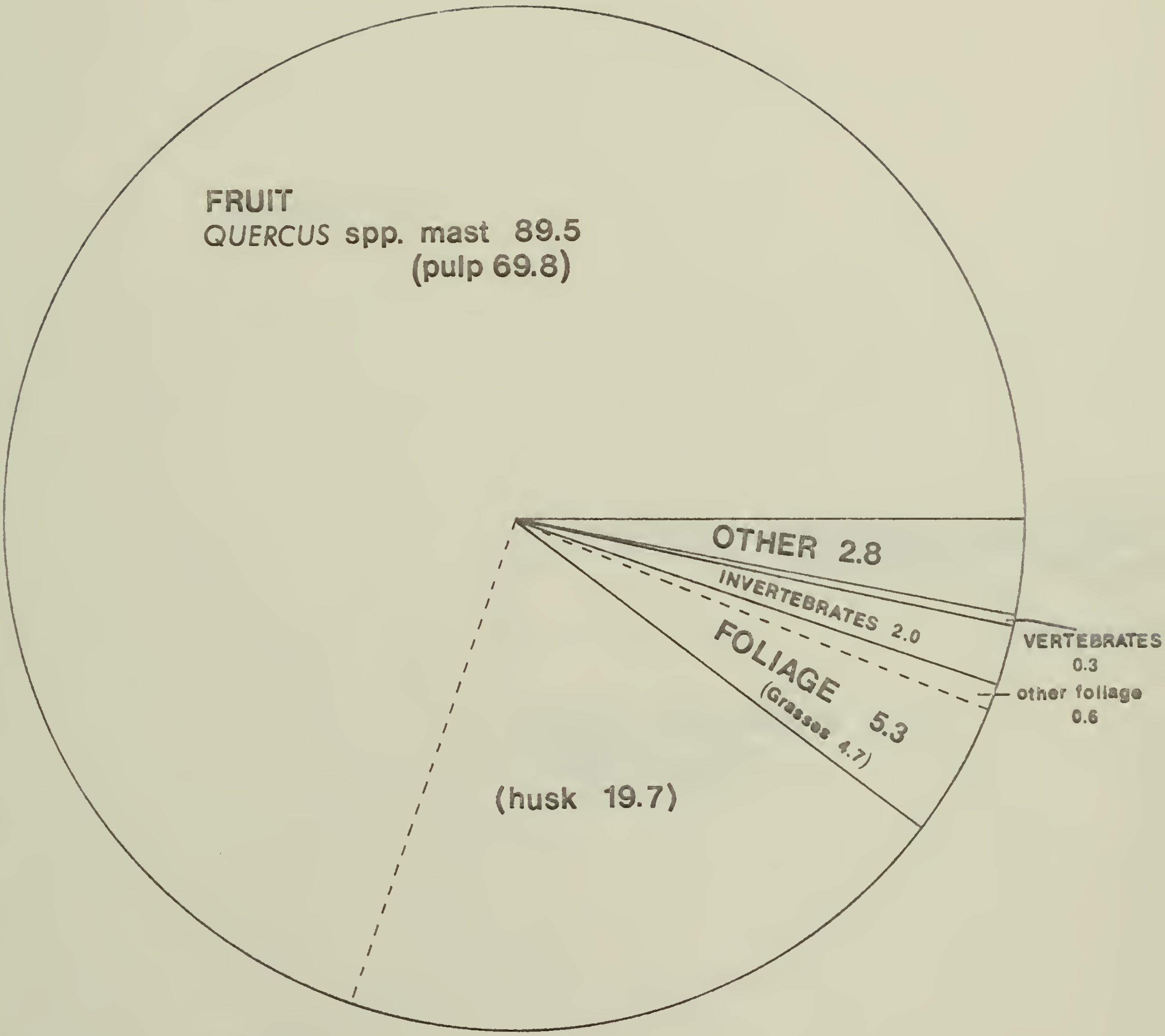
Fungi

Mushrooms and other fungal material were found only during summer at low elevations (18.6 percent). It is not possible to identify these because of considerable mastication and digestion.

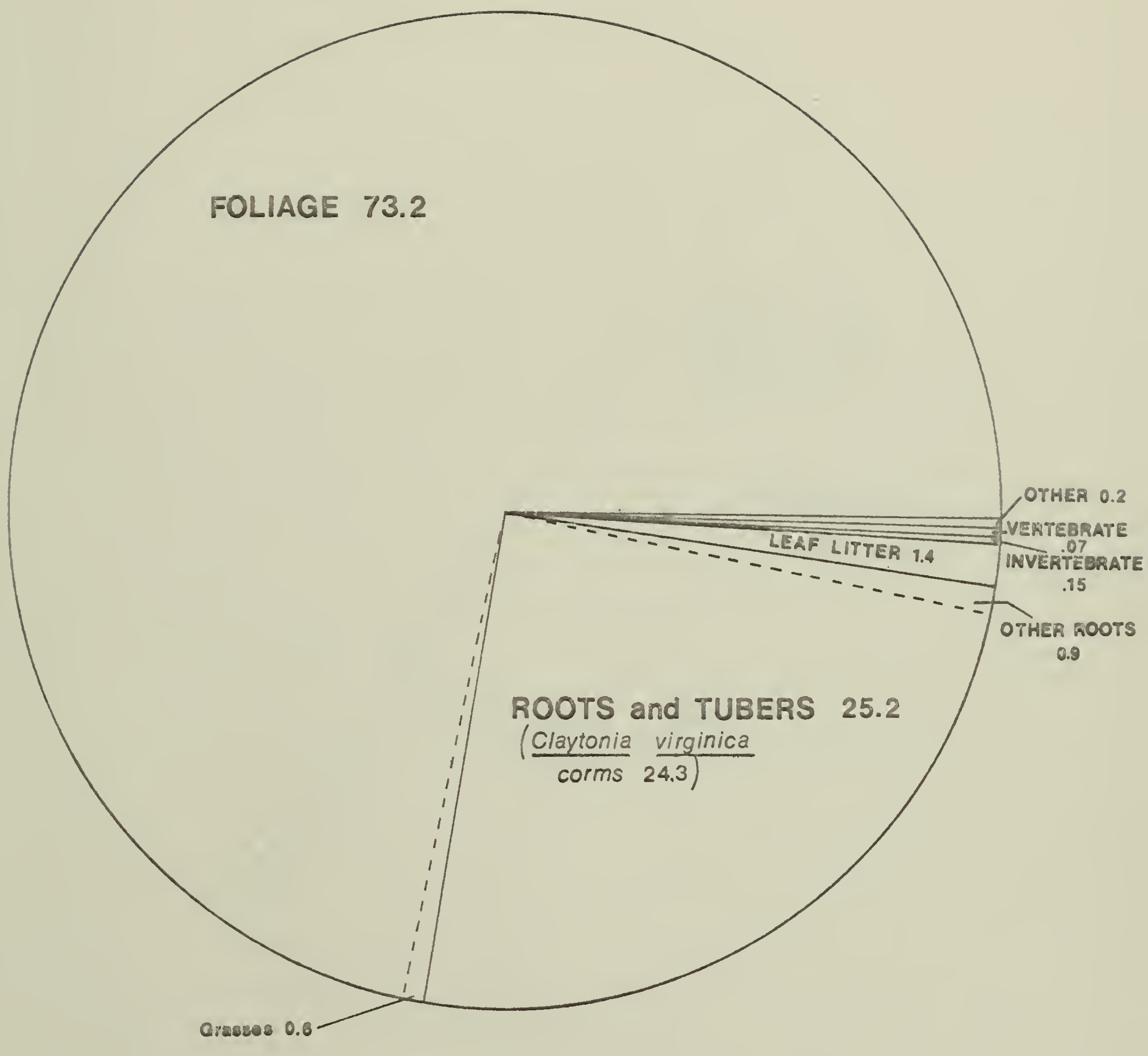
Figure 1. Seasonal percent volume for the various food categories, four seasons, 1976-77.


FRUIT
QUERCUS spp. mast 77.7
(pulp 73.1)
OTHER 2.5
other Invertebrates 3.8
Vertebrates 1.0
INVERTEBRATES 10.3
(Phasmantidae 6.5)
Leaf Litter 1.0
FOLIAGE 7.6
(Carex spp. 2.8)
husk 4.6

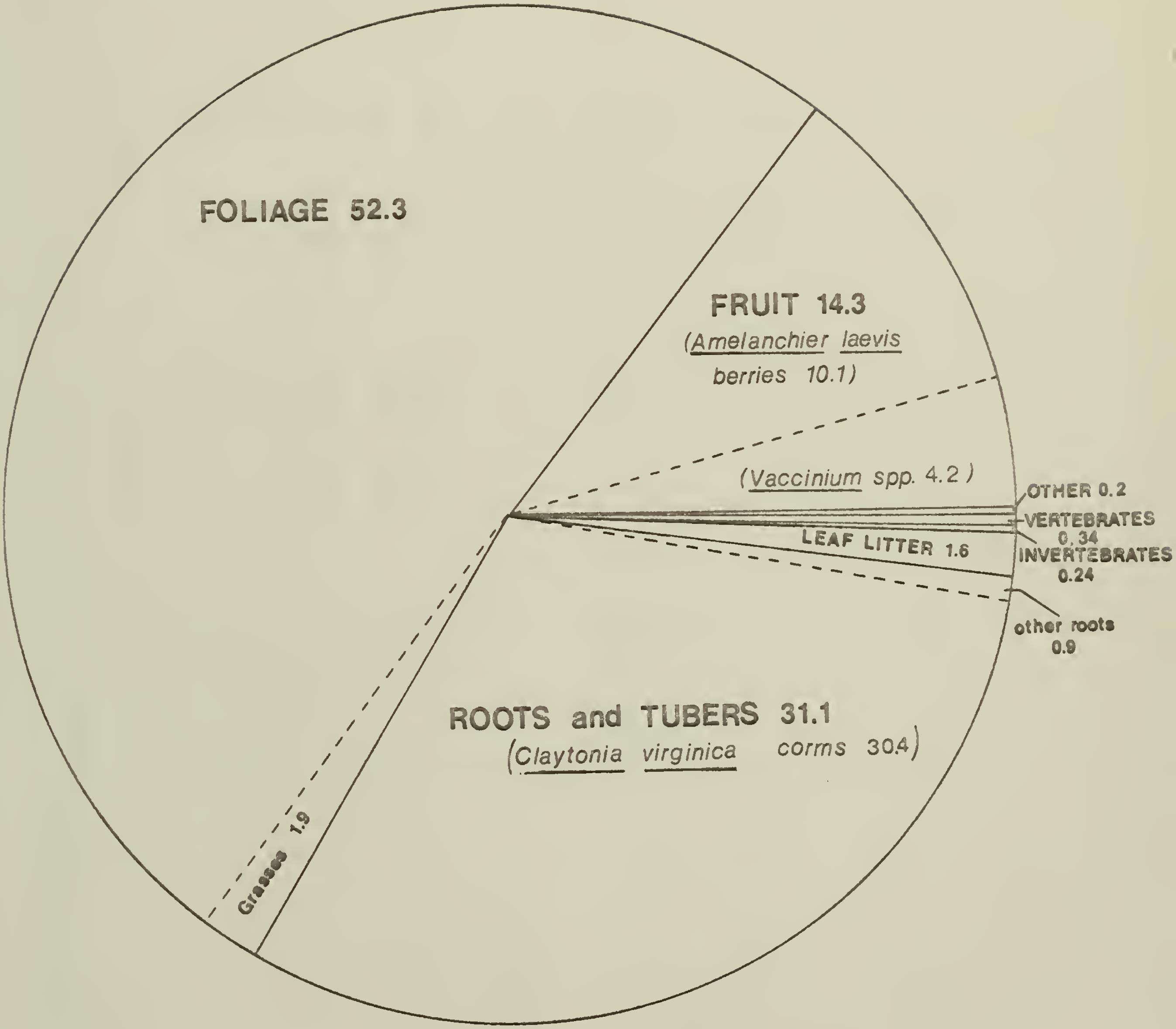
FALL 1976


FRUIT
QUERCUS spp. mast 89.5
(pulp 69.8)
(husk 19.7)
OTHER 2.8
INVERTEBRATES 2.0
FOLIAGE 5.3
(Grasses 4.7)
VERTEBRATES
0.3
other foliage
0.6

WINTER 1977


FOLIAGE 73.2
OTHER 0.2
VERTEBRATE .07
LEAF LITTER 1.4
INVERTEBRATE .15
OTHER ROOTS 0.9
ROOTS and TUBERS 25.2
(*Claytonia virginica* corms 24.3)
Grasses 0.6

SPRING 1977


FOLIAGE 52.3
FRUIT 14.3
(Amelanchier laevis berries 10.1)
(Vaccinium spp. 4.2)
OTHER 0.2
VERTEBRATES 0.34
INVERTEBRATES 0.24
LEAF LITTER 1.6
other roots 0.9
ROOTS and TUBERS 31.1
(Claytonia virginica corms 30.4)
Grasses 1.9

SUMMER 1977

Table 2. Percent volume and percent occurrence of foods taken by European wild boar each season (1976-77) at low elevation sites.

FOODS	FALL		WINTER		SPRING		SUMMER	
	n=5		n=5		n=2		n=3	
	% Vol.	% Occ.	% Vol.	% Occ.	% Vol.	% Occ.	% Vol.	% Occ.
Plant	84.6/	100	94.2/	100	98.8/	100	99.3/	100
Fruit	77.7/	100	89.5/	100	68.2/	100	55.2/	67
Quercus spp.- acorn pulp	73.1/	100	69.8/	100	64.6/	100		
Quercus spp.- acorn husk	4.6/	100	19.7/	100	3.6/	100		
Chaemoneles lagenaria							54.5/	33
Vaccinium spp.							.7/	33
Foliage	2.8/	100	4.7/	80	28.9/	100	10.0/	100
Grasses and sedges (mostly *Carex* spp.)	2.8/	60	4.7/	40	8.3/	100	5.5/	100
Viola spp.					4.6/	50		
Prenanthes spp.					3.4/	50		
Aster spp.					Tr/	50	.7/	33
Unidentified foliage	Tr/	20	Tr/	80	8.0/	100	1.9/	67
Unidentified stems					4.6/	50	1.9/	33

Table 2. Percent volume and percent occurrence of foods taken by European wild boar each season (1976-77) at low elevation sites - Cont.

FOODS	FALL		WINTER		SPRING		SUMMER	
	n=5 % Vol.	% Occ.	n=5 % Vol.	% Occ.	n=2 % Vol.	% Occ.	n=3 % Vol.	% Occ.
Roots and Tubers	Tr/	60	Tr/	80	1.7/	50	13.2/	67
Woody roots							12.0/	33
Unidentified roots	Tr/	60	Tr/	80	1.7/	50	1.2/	67
Fungi (Mushrooms)	--		--		--		18.6/	67
Litter	0.6/	100	Tr/	100			2.3/	67
Twigs and bark							1.0/	33
Acorn shells							0.7/	33
Angiosperm litter (dried leaves, bud scales, etc.)	Tr/	40	Tr/	100			0.6/	33
Gymnosperm litter (*Tsuga canadensis*, *Pinus strobus*, *P. virginiana*, *P. echinata*)	0.6/	60	Tr/	40			Tr/	33
Other	3.5/	40	Tr/	20	--		Tr/	33
Unidentified pulp	3.5/	40	Tr/	20				
Unidentified plant parts							Tr/	33

Table 2. Percent volume and percent occurrence of foods taken by European wild boar each season (1976-77) at low elevation sites - Cont.

FOODS	FALL		WINTER		SPRING		SUMMER	
	n=5		n=5		n=2		n=3	
	% Vol.	% Occ.	% Vol.	% Occ.	% Vol.	% Occ.	% Vol.	% Occ.
Animal	10.8/	100	0.7/	100	.83/	100	.83/	100
Invertebrates	8.2/	100	Tr/	100	.50/	100	.83/	100
Arthropoda Insecta	7.4/	100	Tr/	100	.27/	100	.17/	100
Orthoptera - Phasmidae	6.4/	60						
Neuroptera - Corydalidae					.01/	50		
Coleoptera - Carabidae					.01/	50	.03/	33
Meloidae	Tr/	20	Tr/	20				
Tenebrionidae					Tr/	50	Tr/	33
Scarabaeidae	0.5/	40	Tr/	20	.03/	50	.03/	33
Curculionidae	Tr/	40	Tr/	20				
Unidentified (larvae and pieces)	Tr/	20				.01/100 Tr/50	.02/	66
Lepidoptera - Sphingidae					.12/	50	.01/	33
Unidentified (pupae and larvae)					Tr/	50	.01/	33

Table 2. Percent volume and percent occurrence of foods taken by European wild boar each season (1976-77) at low elevation sites - Cont.

FOODS	FALL		WINTER		SPRING		SUMMER	
	n=5		n=5		n=2		n=3	
	% Vol.	% Occ.	% Vol.	% Occ.	% Vol.	% Occ.	% Vol.	% Occ.
Insecta (cont.)								
Diptera - Tipulidae	Tr/	60						
Bibionidae			Tr/	20				
Tabanidae	Tr/	20	Tr/	20				
Empididae	0.5/	40						
Dolichopodidae	Tr/	20	Tr/	20				
Unidentified larvae			Tr/	20	.08/	50	.07/	100
Hymenoptera - Formicidae					.01/	50		
Unidentified insect			Tr/	20				
Diploda - Juliformia					Tr/	50		
Chilopoda - Scolopendromorpha	Tr/	60			.01/	100	Tr/	33
Crustacea - Decapoda	Tr/	20			.05/	50		
Mollusca: Gastropoda	Tr/	60	Tr/	20				
Annelida: Oligochaeta	0.8/	60	Tr/	20	.17/	50	.66/	33
Aschelminthes: Nematoda					Tr/	100	Tr/	33
Vertebrates								
Mammalia (small mammal, including *Sorex* spp.)	Tr/	60	Tr/	40				

Table 2. Percent volume and percent occurrence of foods taken by European wild boar each season (1976-1977) at low elevation sites - Cont.

FOODS	FALL n=5 % Vol.	 % Occ.	WINTER n=5 % Vol.	 % Occ.	SPRING n=2 % Vol.	 % Occ.	SUMMER n=3 % Vol.	 % Occ.
Aves	Tr/	20	Tr/	20				
Reptilia (turtle)								
Amphibia (salamanders)								
Plethodon cinereus cinereus	.03/	40	.35/	20				
Pseudotriton ruber schencki					.08/	50		
Leurognathus marmoratus intermedius					.04/	50		
Unidentified salamander			.35/	20	.06/	50		
Unidentified tissue	2.6/	60			.15/	50		
Inert	Tr/	100	1.0/	80	Tr/	50	Tr/	33
Rocks, sand, and gravel	Tr/	100	Tr/	80			Tr/	33
Rubber band	Tr/	20						
Plastic					Tr/	50		
Unidentified			1.0/	40	Tr/	50		

Table 3. Percent volume and percent occurrence of foods taken by European wild boar each season (spring and summer 1977) at high elevations.

FOODS	Spring n=11		Summer n=12	
	% Vol.	% Occ.	% Vol.	% Occ.
PLANT	99.8/	100	99.4/	100
Fruit	--		14.3/	42
Amelanchier laevis			10.1/	35
Vaccinium spp. (including *V. corymbosum*, *V. hirsutum*)			4.2/	17
Foliage	73.0/	100	52.2/	100
Laportea canadensis	25.0/	45	10.5/	50
Aster spp.	7.2/	82	17.5/	33
Stellaria pubera	8.0/	82	0.9/	50
Eupatorium rugosum	2.2/	45	5.2/	33
Viola spp.	1.2/	45	5.5/	75
Prenanthes spp.	5.6/	91	0.1/	8
Smilacina racemosa	5.2/	18		
Claytonia virginica	2.4/	27		
Trillium spp.	2.0/	36		
Smilax rotundifolia	Tr/	18	1.1/	8
Rumex acetosella			0.4/	8
Geranium maculatum	0.1/	9		
Oxalis montana	Tr/		0.1/	17
Potentilla spp.			0.1/	8
Vaccinium spp.			0.1/	17
Polygonatum biflora	Tr/	9		
Lilium spp.	Tr/	9		
Thalictrum spp.	Tr/	9		
Grasses and sedges (mostly *Carex* spp.)	0.6/	5	1.9/	42
Unidentified foliage	2.0/	73	4.4/	58
Unidentified stems	11.5/	64	4.4/	83
Roots and tubers	25.2/	100	31.1/	92
Erythronium americanum	24.3/	91	30.4/	75
Viola spp.	Tr/	9		
Unidentified roots and rhizomes	0.9/	27	0.7/	33

Table 3. Percent volume and percent occurrence of foods taken by European wild boar each season (spring and summer 1977) at high elevations - Cont.

FOODS	Spring n=11		Summer n=12	
	% Vol.	% Occ.	% Vol.	% Occ.
Litter	1.4/	73	1.6/	42
Angiosperm litter (dried leaves, bud scales, etc.)	0.9/	58	1.5/	33
Pine needles			Tr/	8
Twigs and bark	0.5/	18	0.1/	8
Other	0.2/	9	0.2/	17
ANIMAL	0.22/	82	.24/	100
Invertebrates				
Arthropods				
Insecta				
Coleoptera Carabidae	.01/	9	.01/	33
Scarabaeidae			Tr/	8
Unidentified pieces	Tr/	27	Tr/	25
Lepidoptera Nocturne			Tr/	8
Unidentified (pupae and larvae)	.02/	9	.01/	33
Diptera Tipulidae			Tr/	8
Unidentified larvae	.06/	18	.07/	58
Diplopoda Polydesmoidea	.02/	27	.01/	50
Juliformia	Tr/	18	Tr/	8
Chilopoda Scolopendromorpha	Tr/	9	.03/	50
Crustacea Decapoda	Tr/	9	.01/	17
Mollusca Gatropoda	.04/	55	.09/	58
Annelida Oligochaeta	Tr/	27	.01/	8
Aschelminthes Nematoda	Tr/	9	Tr/	8

Table 3. Percent volume and percent occurrence of foods taken by European wild boar each season (spring and summer 1977) at high elevations - Cont.

FOODS	Spring n=11		Summer n=12	
	% Vol.	% Occ.	% Vol.	% Occ.
Vertebrates	.07/	46	.34/	50
Mammalia (small mammal)			.21/	17
Reptilia (snake)	.01/	9		
Amphibia (salamanders)				
Plethodon jordani jordani	.05/	36	.09/	42
Plethodon wrighti			Tr/	17
Leurognathus marmoratus intermedius			.02/	8
Desmognathus ochrophaeus carolinensis	Tr/	9		
Eurycea bislineata wilderae			Tr/	8
Unidentified salamanders			.02/	17
(Eggs)			Tr/	8

Invertebrates

Invertebrates were found in all but two stomachs analyzed, although their percent composition is rather low (0.15 - 8.2 percent). Insects and other arthropods, as well as snails (Gastropoda) and earth worms (Oligochaeta), were found. Walking-stick insects (Phasmatidae) were very important during a period in the fall. Other insects found were helgramite (Corydalidae larvae), several families of adult and larval beetles (Coleoptera), caterpillars (Lepidoptera larvae), fly larvae (Diptera), and ants (Hymenoptera). Other arthropods found were millipedes (Diplopoda), centipedes (Chilopoda), and crayfish (Decapoda). There was no recognizable seasonal trend in types of invertebrates consumed, except that earthworms were only eaten during during warm months and at low elevations. There seems to be a trend in volume, however. Fall is very high compared to others, but this may be due to Cades Cove bias.

Vertebrates

Frequency of occurrence for vertebrates was high (45 percent), although percent volume was low (0.0 to 2.3 percent). Salamanders (7 species) were especially common. Best estimates of absolute number of salamanders eaten in summer at high elevations is 1.75 salamanders per stomach, of which 1.33 were the endemic Red-cheeked

salamander (Plethodon jordani jordani), with as many as 7 of that species of salamander in 1 stomach. Salamanders occurred in 53 percent of all stomachs examined. Small mammals were found, but were generally so severely masticated that identification was not made. Mice (Peromyscus spp.) and a shrew (Sorex spp.) were noted. Portions of 2 reptiles were found and also portions of an identified snake and a shell fragment of Eastern box turtle (Terrapene carolina carolina). Several small feathers were found but these may have been consumed as litter. Other unidentifiable animal tissue, which may have been eaten as carrion, was also found.

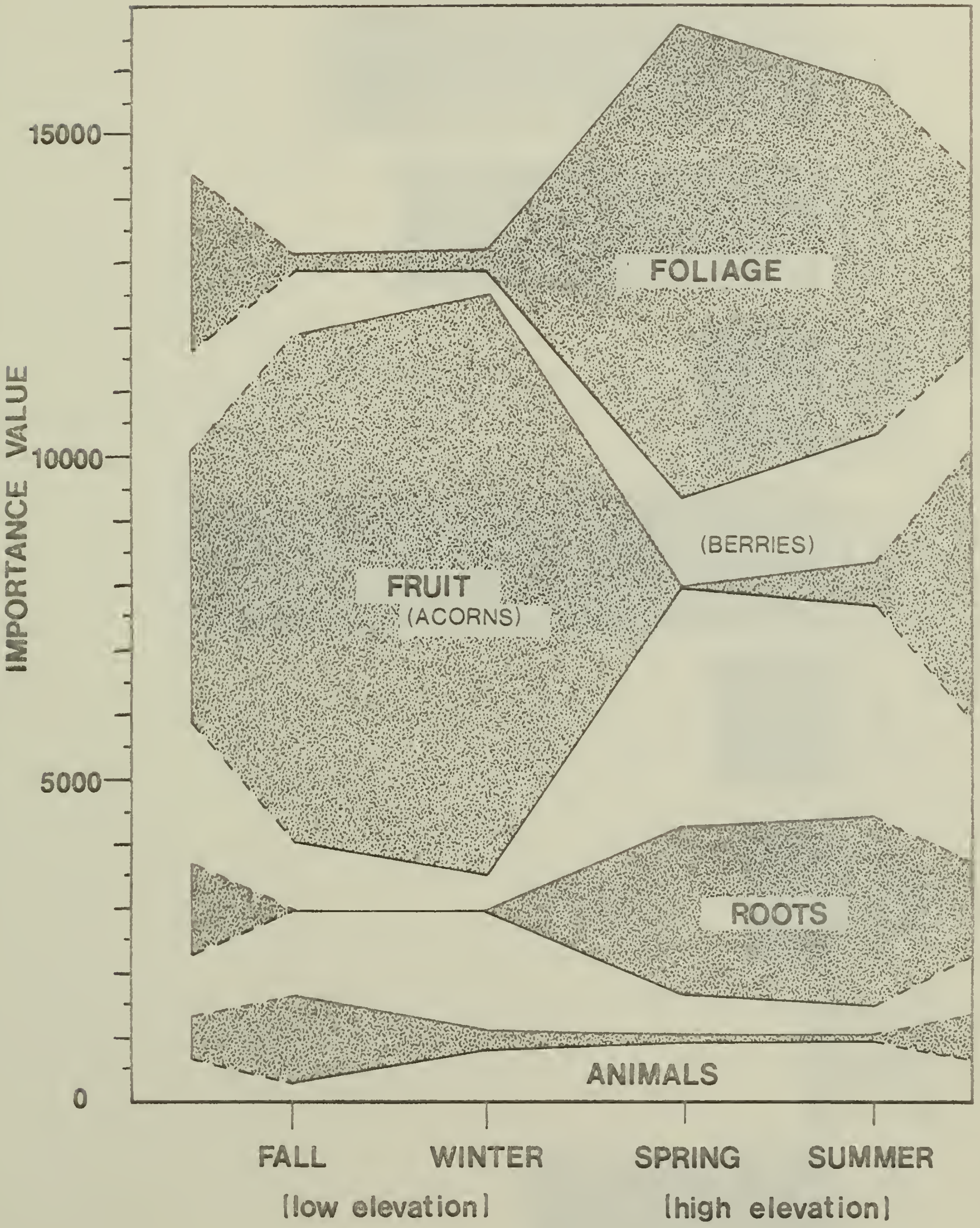
Importance Values

Importance values were calculated for four seasons (fall and winter, low elevation, and spring and summer, high elevation) by multiplying the percent volume by the percent occurrence of each major category of ingesta (Springer 1975). These values have a potential maximum sum of 10,000 for each season (if all animals feed from one single food category). A graphic display of seasonal importance values for major food categories is shown in Figure 2. Importance values for fruits were highest in the fall and winter. Values for foliage and for roots and bulbs were highest in spring and summer. Fungi and animals (invertebrates and vertebrates combined) each had low importance values.

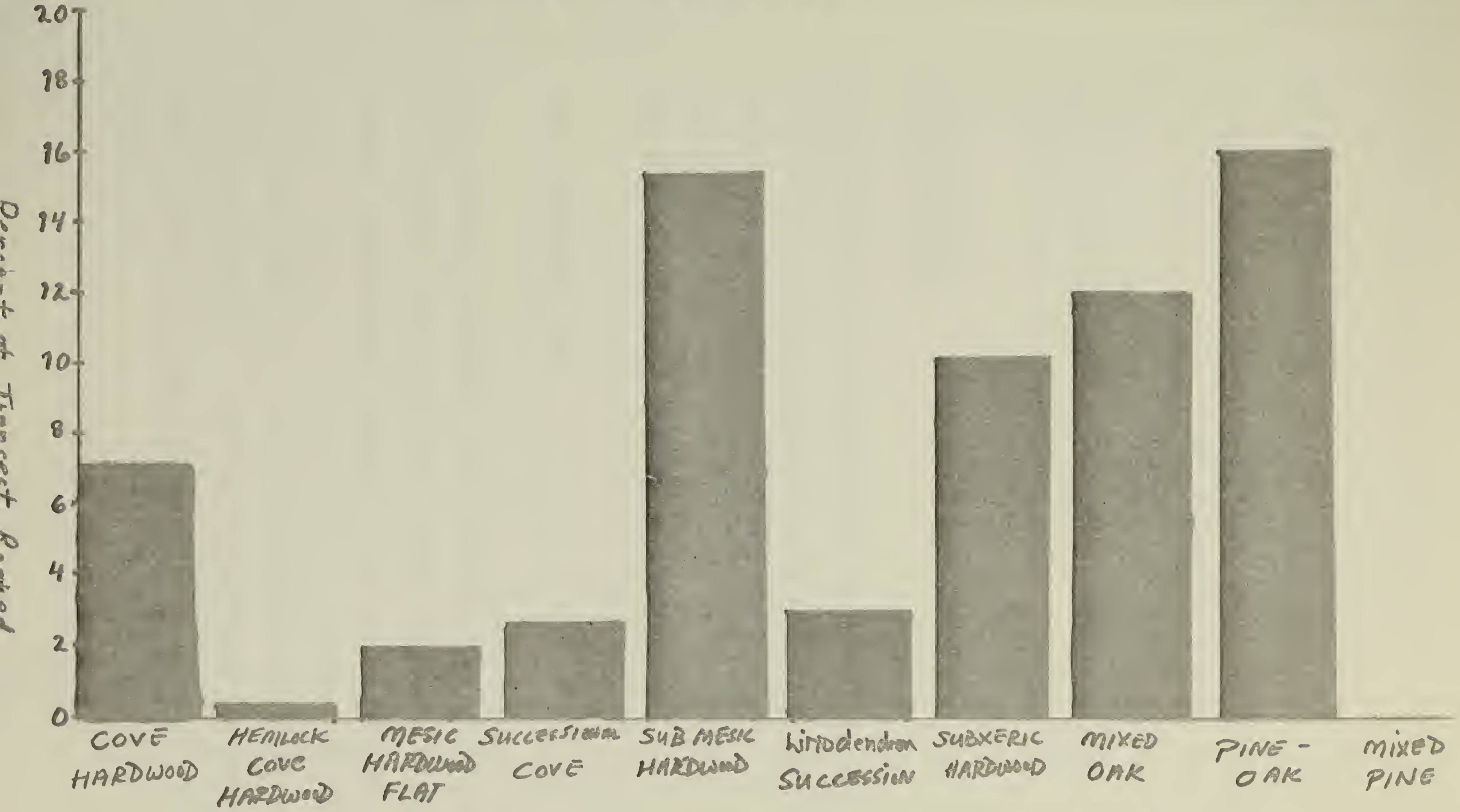
Fall and Winter Rooting

Oaks were major canopy elements in the four most rooted vegetation types (Figure 3). Only the litter layers were disturbed by searching for mast in all types except the successional tulip-poplar (*Liriodendron tulipifera*) type. In this type, A and even B soil horizons were rooted, as Howe and Bratton (1976) described. No rooting was found above 1,000 meters in January or February (deep snow may have been a factor).

Figure 2. Seasonal importance values for general categories of ingesta, 1977.



Winter Season 1976-77



Spring and Summer Rooting

Rooting was deeper during spring and summer at the high elevations and was much more extensive. Percent of transects was highly variable, of course, but many transects in northern hardwoods were > 90 percent rooted, and the average for three locales (n = 60 transects) was 53 percent rooted.

Habitat Relations

We were unsuccessful in correlating food habits to vegetation characteristics, primarily because the wild boar fed throughout the 24-hour period and in doing so, moved through several different vegetation types. We often identified foods eaten which did not occur in the area of a collection site.

Winter Food Habits, 1975

During November and December, 1975, seven hogs were collected in low elevation sites, mostly in the Cades Cove area. Table 4 summarizes the percentage volumes and occurrences. Analysis procedure was the same for fall and winter stomachs. The bulk of the hogs' diet, based on these seven samples, was Chinese yam (*Diosiorea batatas*), comprising 72.3 percent of the total volume. Grasses (16.3 percent) and nuts (8.7%) were the only

Table 4. Percent volumes and occurrences of foods taken by European wild boar in low elevations, winter 1975.

FOOD ITEM	Percent Volume (n=6)	Percent Occurrence (n=7)
Plants	97.5	100.0
Roots and Tubers	72.3	85.7
Chinese Yam	72.3	71.5
Nonwoody	Tr	42.9
Woody	Tr	14.3
Green Foliage	16.3	28.6
Grasses (Graminae)	16.3	28.6
Clover (Trifolium)	Tr	14.3
Fruit	8.9	42.9
Acorns, walnuts	8.7	14.3
Apple skins	0.2	28.6
Animals	Tr	71.5
Invertebrates	Tr	71.5
Centipede	Tr	14.3
Insect larvae	Tr	14.3
Arthropod, unknown	Tr	42.9
Snail	Tr	14.3
Earthworms	Tr	14.3
Vertebrates	Tr	14.3
Unknown entrails	Tr	14.3
Inert	2.5	42.9
Gravel, dirt	2.5	42.9

remaining significant items; however, invertebrates occurred in trace amounts in five (71.5 percent) of the stomachs.

DISCUSSION

Both volumetric and point-analysis methods of stomach analysis proved useful in this study. Robel and Watt (1970) felt the methods provided good results when averaged over several stomachs. We used wet volume only, since it would have proven time-consuming to separate all foliages by species for drying.

Several plant materials were not identified to species level. These included acorns and the leaves of asters and violets. The precision of estimates and foliage composition may not be as high as desirable. However, percent volume by major category is believed to be precise. Because the between-stomach variation is high, precision within one stomach is probably adequate. Further tests of the statistical validity of this method and comparisons between these two sampling methods will be conducted in the upcoming year.

A number of plant and animal species are apparently underestimated due to variation in digestion time. Serviceberries, for example, are usually represented only by their stems. Snail shells dissolve readily, rendering identification impossible and causing their relative volume to be underestimated. The contents of large

insect larvae are squeezed out, with the same effect. Conversely, the hard parts of beetles, crayfish, and millipedes appear to digest slowly. They appear more often as isolated fragments, thus increasing their percent occurrence.

Histological methods proved too costly and time consuming.

Seasonal Availability of Food

Wild boar were shown to be very seasonal in their feeding habits. Movements of boar from low elevations to higher ones near the ridgeline (apparently involving a large proportion of the population) in March and April, and back down in August, are believed to be directly related to the availability of various major plant foods. In addition, there was an obvious ability to fully utilize transient food sources. For example, serviceberries were eaten when they fell to the ground after ripening, between July 6 and July 21. Three out of five animals collected during this period had eaten serviceberries (42, 30, and 7 percent of contents). Blueberries were also eaten in the last week of July and the first week of August by two out of three boars collected during that time (100 and 47 percent of contents).

Throughout the fall and winter seasons of an abundant mast year, acorns were the major food source. These were gathered by

searching and rooting through the leaf litter. This shallow rooting in abundant mast years is probably not as destructive to the leaf litter and soil as other types of rooting. The presence of mast weevils (Curculionidae) indicates that unsound acorns are accepted. Major oak-producing stands are at low elevations. The belief that acorns may still be available (in abundant mast years) at the beginning of the upward migration is supported by two animals who fed primarily on acorns (78 and 64 percent) in mid-May on the North Carolina side of the park at low elevation. On the Tennessee side, the last winter sample, March 5, was 68 percent acorn. The first spring sample, April 5 (cove hardwood, 910 meters), presumably in the process of moving upward, had no acorns but was composed entirely of foliage (100 percent). This was the only sample obtained from mid-elevation. One radio-collared sow took three months to make the ascent to the ridgeline (D. Otto , personal communication). Spring forage could be especially important to sows farrowing or in the late stages of pregnancy while enroute to the ridgeline.

Scott and Pelton (1975) have shown that fall and winter diets change with the availability of mast. During a poor mast year the hogs consume more roots and tubers. This is documented in Table 5 for four winter seasons when compared to mast quality indices from Tellico Wildlife Management Area. Although the Tellico area is west of GRSM, the indices should be similar, since mast quality is relatively constant for a given region

Table 5. Percent volume of spring and summer food habits during a previous GRSM study in 1971-1973, and present study, 1977

STUDY	Apples or quince	Acorns	Berries	Fungi	Woody roots	Nonwoody roots	Forbs	Grass	SAMPLE SIZE
1971-1973*	13	8			6			43	44
1977, low elevations	27	34	Tr	9	6	1	13	7	5
1977, high elevations	0	0	7	0	1	28	61	1	23

* Scott and Pelton (1975)

(Burns et al. 1954). These indices correspond to the following qualities: 2.5 - poor; 2.6 to 4.5 = fair; 4.6 to 6.5 = medium; 6.6 to 8.5 = good; and 8.6 to 10.0 = excellent.

During the mast-poor year of 1975-76, the principal food source was the Chinese yam. Earlier field observations during the winter of 1974-75 strongly suggested that yams were a major food source (Howe and Bratton 1976). It is quite likely that some of the roots and tubers observed by Scott and Pelton (1975) were this species.

Spring and summer diet at high elevations was dominated by foliage. Vernal herbs such as spring beauty, chickweed, violets and trilliums give way to aestival herbs such as asters, white snakeroot, and wood-nettles as the season progresses. These are accompanied by the tubers of spring beauty (24 to 30 percent of diet), which are eaten long after the aerial shoots of this plant have died back. Spring beauty tubers are obtained by deep rooting of the soil, with > 90 percent of the soil surface rooted in the Gray Beech forest by mid-June. Rooting in "hard-to-get-at" places becomes common at that time -- under logs, among tree roots, in campsites, and along trails. Berries become available from mid-July to early August. After these have peaked, there is a rapid movement back to low elevations, presumably to feed on dropping acorns. Several marked animals were observed to be in the Cades Cove area by mid-August, one making a five-mile descent in three days.

Comparison to Other Studies

Data from this study is compared to data gathered in the park in 1971-73 by Scott and Pelton (1975), as shown in Table 5. Our low elevation samples were much like their data; however, the high elevation diet had many more nonwoody bulbs and forbs. Many of Scott and Pelton's (1975) samples were taken in or near Cades Cove, which accounts for the amount of grass and apples found.

Impact of Feeding

The ridgeline area from which stomach samples were taken in 1977 has been occupied by wild boar for 10 to 20 years, and the availability of many forages may already have been affected by their rooting. For example, two plant species heavily damaged by hogs along the invasion front are turk's cap lily (*Lilium superbum*) and purple trillium (*Trillium erectum*); a well-known population of turk's cap lily was selectively rooted east of Double Springs during the summer of 1973 (Bratton 1975). We found neither of these forages nor were they observed on the study area. Both plants are tall and showy with large bulbs and are poorly adapted to resprout after rooting. The major forage eaten in the Spence Field area was spring beauty, which has very small tubers and bulbs (< 1 centimeter in diameter), some of which are always passed by during hog rooting. This species is apparently better adapted to resprouting after mechanical disruption.

Riney (1964) and Caughley (1969) suggest that after liberation and eruptive dispersal of an ungulate, a period of stabilization occurs but is often associated with a modification of the habitat. We therefore hypothesize that tall flowers with large bulbs or tubers are being greatly selected and reduced by the invading wild boar, and that the habitat is modified to support primarily short flowers with small tubers which are capable of surviving hog rooting pressure. We need more samples from near the front of invasion to test this hypothesis.

Salamanders were found in a high frequency of stomachs (53 percent), and their populations could possibly be suffering from this direct reduction. In addition, their survival may be indirectly affected by changes in the habitat through mixing of soil and leaf litter, soil compaction, and erosion after hog rooting. Snails were frequent in the hog's diet (40 percent of stomachs) but their total volume was very low (trace to 0.1 percent). However, the endangered Jones' middle-toothed land snail (Mesodon jonesianus occurs within the hogs' newly occupied range at Newfound Gap, and their predation may prove highly detrimental to the snail's population. More studies are needed on the distribution and status of such possibly impacted species.

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APPENDIX

PART II.

Table 1. Location, vegetation type, and sex and age data of research specimens, 1976-77.

Vegetation Type

PPO = Pasture (pasture-pine-oak
MO = Mixed oak
CH = Cove hardwoods
GB = Gray Beech forest
NH = Northern hardwoods
GR = Grassy bald
PO = Pine-oak

Sex

M = Male
F = Female
U = Unidentified

Age

m = Months old
y = Years old

LOW ELEVATION

	Date	Number	Location	Vegetation Type	Sex	Age	Condition	Elevation (meters)
Fall	10/29/76	1*	Cades Cove, TN	PPO	U	+ 26 m	2	530
	10/30	2*	Sinks, TN	MO	M	(juvenile)	2	520
	11/10	3	Cades Cove, TN	PPO	M	(adult)	3	530
	11/10	4	Cades Cove, TN	PPO	F	(juvenile)	3	530
	11/10	5	Cades Cove, TN	MO	M	+ 26 m	3	530
	11/10	6*	Cades Cove, TN	MO	M	(juvenile)	3	530
	11/17	14*	Parsons Branch Road, TN	MO	M	(adult)	4	790
	12/8	7	Cades Cove, TN	PPO	M	26 m	2	530
	12/9	8	Laurel Creek Road, TN	MO	M	4 y	3	625
	n = 9							

*Samples not used.

Table 1. Location, vegetation type, and sex and age data of research specimens, 1976-77 - Cont.

LOW ELEVATION (cont.)

	Date	Number	Location	Vegetation Type	Sex	Age	Condition	Elevation (meters)
Winter	1/3/77	9	Cades Cove, TN	PPO	M	(adult)	3	530
	1/18	11	Tunnel Road (9A), NC	MO	M	4-5 y	3	610
	2/1	13	Tunnel Road (9A), NC	MO	M	7 y	3	750
	2/17	19	Metcalf Bottoms, TN	MO	M	26+ m	4	610
	3/5	17	Cades Cove, TN	PPO	M	3 y	3	530
	n = 5	(1 other, mislabeled - sample not used)						
Spring	5/17/77	40	Olke Branch, NC	PO	F	26+ m	1	550
	5/24	42	Pikes Creek, NC	PPO	M	4-6 m	--	610
	n = 2							
Summer	8/9/77	106	Cades Cove, TN	PPO	M	5 y	1	550
	9/1	107	Hazel Creek, NC	PPO	F	18-22 m	3	550
	9/10	108	Laurel Creek, TN	MO	M	7 y	--	518
	n = 3							

Table 1. Location, vegetation type, and sex and age data of research specimens, 1976-77 - Cont.

HIGH ELEVATION

	Date	Number	Location	Vegetation Type	Sex	Age	Condition	Elevation (meters)
Spring	4/6/77	69	Tremont-Thunderhead Trail, TN	CH	M	2-4 m	3	910
	5/18	59	Rich Gap	NH	F	(adult)	4	1,460
	5/23	38	Rocky Top	GB	M	18-20 m	--	1,550
	5/24	39	Rocky Top	GB	M	3 y	3	1,650
	5/24	44	2 Miles north of Sheep Pen Gap, TN	NH	F	(adult)	3	1,070
	5/31	50	Rich Gap	NH	F	5 y	3	1,400
	6/11	51	Doe Knob	NH	F	21-26 m	4	1,400
	6/1	55	Rocky Top	GB	F	4 y	4	1,520
	6/1	56	Rocky Top	GB	F	26+ m	4	1,590
	6/13	62	Sheep Pen Gap	NH	F	5 y	3	1,370
	6/14	57	Derrick Knob	GB	F	3 y	3	1,340
	n = 11							

Table 1. Location, vegetation type, and sex and age data of research specimens, 1976-77 - Cont.

HIGH ELEVATION (cont.)

	Date	Number	Location	Vegetation Type	Sex	Age	Condition	Elevation (meters)
Summer	7/2/77	73	Thunderhead Mountain	GB	M	4-6 m	3+	1,650
	7/3	74	Mineral Gap	GB	M	6-8 m	3+	1,540
	7/3	75	Mineral Gap	GB	F	18-21 m	3+	1,520
	7/3	76	Mineral Gap	GB	M	10-21 y	3	1,520
	7/6	93	Sheep Pen Gap	NH	M	(piglet)	--	1,430
	7/14	94	Mollies Ridge	NH	F	18-20 m	--	1,510
	7/21	90	Spence Field	GB	F	4-6 m	3	1,480
	7/21	91	Spence Field	GR	M	4 y	3	1,490
	7/21	92	Spence Field	GR	F	16-18 m	3	1,490
	7/27	96	Gregory Bald	GR	F	4-6 m	3	1,510
	8/1	102	Gregory Bald	GR	F	6-8 m	3	1,510
	8/2	95	Little Bald	GB	F	4-6 m	3	1,450
	n = 12							

Table 2. Plant and animal species found in stomach samples from European wild boar, 1977

A = Acorn
L = Leaves
R = Roots or tubers
F = Fruits
N = Needles

Plants		Part Consumed
Allegheny Serviceberry	*Amelanchier laevis*	F
White Wood Aster	*Aster divaricatus*	L
Heart-leaved Aster	*A. cordifolius*	L
Sedges	*Carex* spp.	L
Japanese Quince *	*Chaenomeles lagenaria*	F
Spring Beauty	*Claytonia virginica*	L, R
Trout Lily	*Erythronium americanum*	R
White Snakeroot	*Eupatorium rugosum*	L
Wild Geranium	*Geranium maculatum*	L
St. Johnswort	*Hypericum hypericoides*	F
Wood-nettle	*Laportea canadensis*	L
Lily	*Lilium* spp.	L
Common Wood Sorrel	*Oxalis montana*	L
Shortleaf Pine	*Pinus echinata*	N
White Pine	*P. strobus*	N
Scrub Pine	*P. virginiana*	N
Solomon's Seal	*Polygonathum biflorum*	L
Cinquefoil	*Potentilla* spp.	L
Rattlesnake-root	*Prenanthes* spp.	L
White Oak	*Quercus alba*	A
Scarlet Oak	*Q. coccinea*	A
Southern Red Oak	*Q. falcata*	A
Chestnut Oak	*Q. prinus*	A
Red Oak	*Q. rubra*	A
Sheep-sorrel *	*Rumex acetosella*	L
False Solomon's Seal	*Smilacina racemosa*	L
Common Greenbrier	*Smilax rotundifolia*	L
Great Chickweed	*Stellaria pubera*	L, F
Meadow Rue	*Thalictrum* spp.	L
Purple Trillium	*Trillium erectum*	L
Yellow Trillium	*Trillium luteum*	L
Eastern Hemlock	*Tsuga canadensis*	N
Highbush Blueberry	*Vaccinium corymbosum*	F, L
Hairy Blueberry	*V. hirsutum*	F
Sweet White Violet	*Viola blanda*	L
Halberd-leaved Yellow Violet	*V. hastata*	L
Northern White Violet	*V. pallens*	L
Grasses		L
Mushrooms		Fruiting body or F (?)

*Introduced

Table 2. Plant and animal species found in stomach samples from European wild boar, 1977 - Cont.

A = Adult
E = Egg

L = Lavae
P = Pupae

Animals

	Vertebrates		Age Consumed Stomach Contents
Mouse	Mammelia -	*Peromyscus*	A
Shrew		*Sorex*	A
Bird	Aves		Feather
Eastern Box Turtle	Reptilia -	*Terrapene c. carolina*	A
Snake, unidentified			Shell fragment
Blue Ridge Mt. Salamander	Amphibia -	*Desmognathus ochrophaeus carolinensis*	A
Pigmy Salamander		*D. wrighti*	A
Blue Ridge Two-lined Salamander		*Eurycea bislineata wilderue*	A
Southern Shovel-nosed Salamander		*Leurognathus marmoratus intermedius*	A
Red-backed Salamander		*Plethodon c. cinereus*	A
Red-cheeked Salamander		*P. j. jordani*	A
Black-chinned Red Salamander		*Pseudotriton ruber schenki*	A

	Invertebrates		
Walking-sticks	Othoptera	Phasmantidae	A
Dobsonflies (Hellgrammite)	Neuroptera	Corydalidae	L
Ground Beetles	Coleoptera	Carabidae	A
Snout Beetles (weevils)		Curculionidae	L
Blister Beetles		Meloidae	L
Scarab Beetles		Scarabaeidae	L
Darkling Beetles (mealworms)		Tenebrionidae	L
Noctuid Moths	Lepidoptera	Noctuidae	L
Sphinx Moths		Sphingidae	L, P
March Flies	Diptera	Bibionidae	L
Long-legged Flies		Dolichopodidae	L
Dance Flies		Empidae	L
Horse Flies		Tabonidae	L
Crane Flies		Tipulidae	L

Table 2. Plant and Animal species found in stomach samples from European wild boar - Cont.

	Invertebrates (cont.)	Age Consumed Stomach contents
Ants	Hymenoptera Formicidae	A
Millipedes	Diplopoda Polydesmoidea	A
Millipedes	Juliformia	A
Centipedes	Chilopoda Scolopendromorpha	A
Crayfish	Crustacea Decopoda	A
Earthworms	Annelida Oligochaeta	A
Snails	Mollusca Gastropoda	A
Nematode worms	Aschelminthes Nematoda	A

Table 3. Plant phenology and major hog movements onto the ridgetop study area, 1977.

		Trees					% Hog Rooting
		Beech	Red Oak	Red Maple	Buckeye	Yellow Birch	
	1	--	--	--	--	--	No hog sign Tr
April	15	--	--	--	--	--	21
	30						
May	15	Partial leaf out	Partial leaf out	Partial leaf out	Partial leaf out	Partial leaf out	68
	30	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	83
June	15	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	91
	30	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	96
July	15	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	90
	30	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	92
August	15	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	30
	30	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	21
Sept.	15	Leaf out	Leaf out	Leaf out	Leaf out	Leaf out	Tr
	30	Partial leaf drop	Leaf out	Leaf out	Partial leaf drop	Wilt	0
Oct.	15	Partial leaf drop	Leaf out	Leaf out	Partial leaf drop	Partial leaf drop	0
	30	Leaf drop	Partial leaf drop	Leaf out	Leaf drop	Leaf drop	0

Table 3. Plant phenology and major hog movements onto the ridgetop study area, 1977 - Cont.

		Herbs		Berries			
		Compositae	Trout Lily Spring Beauty	Serviceberry	Blueberry	Rubus	% Hog Rooting
	1						
			Flower				Tr
April	15						
			Partial wilt				15
	30						
			Wilt				72
May	15						
			Wilt	Flower			85
	30						
							94
June	15						
							72
	30						
				Fruit peak			88
July	15						
		Flower		Berry drop	Fruit peak	Fruit peak	90
	30						
					Berry drop		31
August	15						
							Tr
	30						
Sept.	15	Wilt		Leaf drop	Partial leaf drop		0
	30						0
Oct.	15						0
	30						0

Table 4. Number of salamanders found in hog stomachs, 1977, by season.

Salamander Species	Number found in low elevations				Number found in high elevations	
	Fall	Winter	Spring	Summer	Spring	Summer
Plethodon jordani jordani					6	16
Plethodon wrighti						1
Pseudotriton ruber schencki			1			
Eurycea bislineata wilderae						1
Leurognathus marmoratus intermedius			1			1
Desmognathus ochrophaeus carolinensis					1	
Plethodon cinereus cinereus	?	?				
Unidentified						2
TOTAL			4	0	7	21
e[illegible]cent of stomachs with salamanders	40	20	50	0	27	50
Num[illegible]er of salamanders per stomach	?	?	2.0	0.0	.6	1.75